A Nuffield Farming Scholarships Trust Report

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Sustainable pig nutrition

Michelle Sprent

July 2014

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A Nuffield (UK) Farming Scholarships Trust Report

Date of report: July 2014

"Leading positive change in agriculture.
Inspiring passion and potential in people."

Title	Sustainable pig nutrition
Scholar	Michelle Sprent
Sponsor	BPEX & Merial
Objectives of Study Tour	To explore the future of ingredients used in pig nutrition.
Countries Visited	Canada (Mar 2013) China (Aug 2013) Turkey (Nov 2013) Australia (Nov 2013) Brazil (Apr 2014) Netherlands (July 2014)
Findings	• Soya and cereals (wheat or corn/maize) are the dominant feed ingredients globally and this will continue for the foreseeable future • Producers of feed ingredients are endeavouring to reduce their environmental impact • Alternative ingredients do exist but they face the same environmental/sustainability challenges facing conventional ingredients, such as water and land availability • Feed and food safety are critical when considering alternative raw materials • Waste reduction throughout the food chain from farm to fork is essential - management and precision from the soil to the slaughterhouse is essential to improve sustainability

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DISCLAIMER

The opinions expressed in this report are my own and not necessarily those of the Nuffield Farming Scholarships Trust, or of my sponsor (BPEX and Merial), my employer Premier Nutrition (AB Agri) or of any other sponsoring body.

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1. Introduction to Michelle Sprent

I have been working as a pig nutritionist since graduating in 1999. Although not from a farming background, I actually started feeding pigs indirectly at the age of 14 when I got my first job working in a greengrocer's shop. We used to collect all our waste fruit and veg into "spud" sacks for "Frank the Pig Man" to collect every Saturday. I had no idea at the time that I would go on to spend my career in pig nutrition!

Having completed my A Levels I went on to study Nutritional Biochemistry at the University of Nottingham, and this led me into the field of livestock nutrition. I was offered a place on an MSc course at the University of Aberdeen to study Pig Production, during which I specialised in pig nutrition.

Before graduating from Aberdeen I'd managed to secure a job with SCA NuTec where I worked for the next 11 years. In my early years of training to become a nutritionist I worked on piglet feed research trials and raw material quality control for the feed mill, as well as providing technical support to customers and the sales team. I gradually became involved in the export side of the business and worked in Germany, Denmark, Austria and South Korea. In 2010, I moved to work for Premier Nutrition (manufacturers of vitamin and mineral premixes for all species) providing on farm technical support to UK and Irish pig producers who are home mixing their feeds. In addition, I work with a feed compounder in South Korea providing technical support.

Picture 1 : Me, Michelle Sprent, amid sunflowers in Mato Grosso, Brazil

2. Background to the study

In pig production, feed costs can account for up to 70% of the cost of production. In recent years the key ingredients used in UK pig diets i.e. cereals and soya, have been experiencing ever increasing price volatility. These products are now traded globally and are therefore heavily influenced by global economics and demands. When I joined the feed industry in 1999 hipro soya was £140/tonne. It steadily increased and hit a massive high of around £440/tonne in the summer of 2012 and is currently trading at just above £300/tonne (July 2014). In addition, growing demand from new and emerging countries within their livestock sectors is putting increasing pressure on the availability of these ingredients. In order to keep pace with global demand for products such as soya, more volume needs to be produced. This is causing debate about the environmental impact, and increasing production of soya is being blamed for the destruction of environmentally important areas such as the Amazon rainforest.

A large proportion of my work is with pig producers who are utilising liquid co-products. This includes products such as wheat distillers' syrups from the biofuel sector and liquid yeasts from the brewing industry. My work has led me to have a greater interest in less conventional feed ingredients for pigs, which may offer a more sustainable and cost effective alternative to the more common raw materials such as soya.

By undertaking a Nuffield Farming Scholarship I hope to be able to transfer knowledge and experience to our UK producers, to help improve their businesses, and ensure they can cost-effectively and sustainably produce high quality pigs in the future.

Through my Nuffield Farming Scholarship, I hoped to investigate how other markets such as the Netherlands are utilising co-products; how they are approaching the problem of ever increasing volatility in the cost and supply of conventional ingredients. Also, what alternative raw materials are being investigated and developed - for example, in Canada. I was also hoping to explore what the future holds for conventional ingredients for pigs. As part of this, I wanted to visit ingredient producers such as the South American soya growers, to see how they envisage the future for their crops. I was very keen for my Scholarship to help me develop not only my knowledge of ingredients and global pig production, but also to extend my network of contacts.

By undertaking a Nuffield Farming Scholarship I hope to be able to transfer knowledge and experience to our UK producers, to help improve their businesses, and ensure that they can cost-effectively and sustainably produce high quality pigs in the future.

3. Global pig and livestock production

The Food and Agriculture Organisation of the United Nations estimates there will be 11 billion pigs by 2015, which is double the number there was in the 1970s (www.fao.org).

Globally pigmeat contributes 36% of total meat consumed, whilst beef represents 24% and poultry 33%. While meat consumption in the *developed* world has remained relatively static since the 1980s, meat consumption in the *developing* world has almost doubled. On average, around the world, 15.8kg of pigmeat is consumed per capita per annum (*Australian Pork, Australian Pig Annual 2011-2012).*

Globally pigmeat contributes 36% of total meat consumed, whilst beef represents 24% and poultry 33%.

This increase in meat consumption is expected to continue, which means livestock production is expected to double by 2050. This is in part due to the increasing global population which is estimated to reach 9 billion by 2050 (from 7 billion in 2013). It is also due to the fact that developing countries are increasing the percentage of meat in their diets as they become more affluent. In terms of pigmeat, the *developing* countries are increasing meat consumption by about 20% whilst the average annual consumption in the *developed* world is virtually unchanged.

Between 2004 and 2013 aquaculture grew at a rate of 5.6% per annum and the projected production for 2023 is expected to be 92 million tonnes, which is a staggering 38% increase

Before embarking on my Nuffield Farming Scholarship, I had not been aware of the rate of development in aquaculture i.e. farmed rather than wild fish. Between 2004 and 2013 aquaculture grew at a rate of 5.6% per annum and the projected production for 2023 is expected to be 92 million tonnes, which is a staggering 38% increase (*OECD-FAO Agricultural Outlook 2014 Fish & Seafood).*

This increase in demand for livestock and aquaculture products which are reared using finite resources is clearly a huge challenge for the future of agriculture.

3. Countries visited

During my Nuffield Farming Scholarship study tour I visited Canada, China, Turkey, Australia, Brazil and the Netherlands as well as attending some meetings in the UK. In Table 1, there is a summary of the sow population of the countries I visited, together with an estimate of the number of pigs produced annually in that country. I visited Turkey for a US Soya Export Council (USSEC) European Buyers meeting and because they are not a pig producing country these have been omitted from the table.

Table 1: Sow population and Number of slaughter pigs produced per annum in the countries visited

Country	Sow Population	Slaughter Pigs/annum	Source & Year
Canada visited March 2013	1.2 million	11.65 million	2012 Statistics Canada via www.thepigsite.com
Netherlands visited July 2014	1.065 million	5 million	2012 Eurostat via www.thepigsite.com
United Kingdom	0.425 million	10.3 million	BPEX Pig Pocketbook 2013
Brazil visited April 2014	2.9 million	35 million	ADHB Country Report Jan 2013 via www.pigsite.com
China visited August 2013	49.3 million	688 million	ADHB Country Report Nov 2012 via www.pigsite.com
Australia visited Nov. 2013	0.26 million	5.6 million	Australian Pork Australian Pig Annual 2011-2012

NB: Canada sends a proportion of their finished pigs to slaughter in the US, and the Netherlands send pigs to other European countries at weaning/30kg stage for finishing and slaughter.

4a. Canada

I visited Canada initially as part of the Nuffield Farming-organised Contemporary Scholars Conference (CSC). This meeting gathers together all the current year's Scholars from participating countries for a series of presentations and discussions about global agriculture.

Following the CSC I decided to remain in Canada to begin my individual study. Canada has a strong pig industry with a good research base.

My first visits took me to Grand Valley Fortifiers (GVF) in Ontario, a business producing vitamin and mineral premixes and piglet starter feeds. GVF also owns a business called Progressive Recycling which processes products such as biscuits and confectionary waste into approximately 350-400 tonnes per week of "biscuit meal" for use in animal feeds. While in Ontario, GVF took me to visit one of their customers who utilises liquid co-products. I also visited a feed business in Alberta called Nutrition Partners which was originally established by my current boss and other founder members of Premier Nutrition. I met with Jan Geerts who is the Director of Swine Nutrition and spent some time discussing the types of ingredients being used in Canadian pig diets.

Much of my time in Canada was with university-based researchers. I met with Kees de Lange at the University of Guelph who has published many research papers in the field of pig nutrition. He is an author of the new National Research Council's "Nutrient Requirements of Swine" and in addition has been heavily involved in completing studies in collaboration with the Canadian "Swine Liquid Feed

Association" (SLFA). Kees was asked by the SLFA to research some aspects of the products they are using to give some "credibility" to their use of co-products.

I also visited the University of Saskatchewan where I met with Tom Scott and John Smilie to talk about the work they are doing on feed processing, to try to improve efficiencies in livestock production. Hank Classen discussed oilseed rape processing whilst Albert Vandenburg talked about lentils and other pulse production in Canada. I was given a tour of the research facilities at the Prairie Swine Centre which carries out some excellent fundamental research as well as very practical production-based trials, the results of which can be readily applied on commercial farms. My final visit was with Ruurd Zilstra at the University of Alberta, who is recognised in nutrition circles as an expert on rape seed and wheat by-products. He has written many articles on the use of dry co-products such as dried distillers grains with solubles (DDGS) in pig feeds.

Picture 2 : visiting the Prairie Swine Centre in Saskatoon, Canada

4b. China

China is the world's largest pig producer and they raise over 51% of the world's pigmeat. It is estimated that they have somewhere between 46 and 52 million sows. The estimate is sketchy as many of these exist as a handful of sows in a "back yard" situation, although this position is changing rapidly. In addition, a Chinese business in 2013 bought out the largest US pig producer, Smithfield, which means they now have a stake in 862,000 sows in the US and a total of over 1 million sows globally. From a feed perspective, they are also very influential as they are the world's largest importer of soya.

I had been fortunate to have visited China on a business trip to take part in a creep feeding seminar held in Shanghai in June 2013. I was invited by a sister company, ABCA, an AB Agri business specialising in co-products and feed additives in the Asian market, to present at this seminar. The team from ABCA then very kindly hosted me for a further three weeks for a Nuffield Farming visit.

My first week in China was spent in Shangdong province. Agriculture dominates this province with pig production, broilers, maize, vegetables and fruit all being produced in abundance. There are 33 provinces in China with about 10-13 of these being important pig areas. Shangdong has roughly 2 million sows and falls into the category of an important pig area. As with the figure for the total population of China, the sow herd number is a rough guess as no one seems to really know! I met with six businesses ranging across the whole province, from a Korean-run pig unit with 1500 sows to a newly formed feed business which has a target of producing 1 million tonnes of feed by 2015, from a standing start at the beginning of 2013. To put this feed business into context the total retail (compound) pig feed production in GB currently stands at almost 1.7 million tonnes (*DEFRA statistics*).

One of the businesses I visited started out as a slaughter house and decided to become a fully integrated business. By the end of 2013, they planned to have 10,000 sows all fed by their own newly built feed mills. The picture below shows the finisher buildings under construction on one of their farms. Their ambition is to be producing 600,000 finishers by 2016. The speed and level of investment and growth in China is amazing!

Picture 3 : finisher buildings under construction in Shangdong Province, China – the scale and speed of growth in China is fascinating.

The timing of my China visit worked perfectly for ABCA as this coincided with a three-venue nutrition seminar they were organising and they took the opportunity to request a repeat of my previous presentation. The seminar was being co-hosted by Topigs, with Glen Illing and George Aretis from the Topigs Asia team presenting. The seminar visited Guandong, Jinan and, finally, Beijing.

My final week took me to the far North East corner of China into Heilongang Province which borders Mongolia and Russia. I visited a "State Farm" where Yao Bin, who now works for ABCA, was brought up. The farm is one of nine sub bureaus (distributed throughout China) and mainly produces maize (corn) and soya. The town we stayed in only exists because of the farm. Of the 300,000 strong population, 100,000 of them are employed by the farm. When the area was first populated it was virgin land which the army cleared and began to farm. The farm is operated in a very professional manner and prides itself on application of the latest in global technology. I was told there is a 50 year gap in terms of technology between the State farms and the privately owned small traditional farms.

The town we stayed in only exists because of the (State) farm. Of the 300,000 strong population, 100,000 of them are employed by the farm.

5c. Turkey

I visited Turkey to attend a US Soya Export Council (USSEC) meeting. This was their 3rd Annual European Buyers' Meeting and was focussed on Trade and Sustainability. Whilst Europe, relative to countries such as China, is becoming a smaller player in the importation of soya, it is still an important export market for the US soya producers. The meeting presented the global trends in soya production and consumption and also presented the US Soya Sustainability protocol.

5d. Australia

I hadn't originally intended to go to Australia as they are a relatively small pig producer with 240,000 sows. However, the Australasian Pig Science Association (APSA) holds a very good meeting which showcases the good quality pig research work they do, along with a selection of invited papers presented by eminent researchers from around the world. APSA's Manipulating Pig Production meeting is held every 2 years and, whilst I was in Australia, it allowed me to visit pig producers using different feeding systems and gain an insight into their perspective of sustainability.

I had the opportunity to visit two pig units near Melbourne, one using conventional dry feed and the other making excellent use of a variety of co-products. The co-product visit was organised and accompanied by Dave Cadogan, a nutritionist with a business called Feed Works who is also the Chairman of APSA, so we had a full day of talking nutrition. I also had a discussion about feed and Australian ingredients with Weston Milling's nutritionist, Christine Sydenham.

The rest of my stay in Australia strayed a little from my topic but gave me the opportunity to visit some of the 2013 Australian Nuffield Scholars who are farming sheep, broilers, chillies, sugar cane and fibre crops, all facing the same challenge of finite resource and environmental impact. My final visit was to a farm producing AUS$4 million worth of mangoes p.a.!

5e. Brazil

Brazil was a "must visit" country for this topic as they are not only the world's third largest pig producer but they are also high on the radar of environmentalists. This is because of their massive production of corn/maize and soya, amongst every other agricultural commodity that Brazil is capable of growing. Brazil produces large quantities of pigmeat for domestic consumption and is also a very important producer from an export perspective.

Traditionally, pig production has taken place in the more southern states such as Santa Catarina; however, pig production is now developing in the central western state of Mato Grosso. The start of my visit took me to see a mixture of pig production, crop production and pig processing in Mato Grosso. I also visited a Government funded (EMBRAPA) research station which is focussed on the integration of grazing and crop production with forestry, as well as looking at techniques to re-establish native woodland.

A visit to the Federal University of Minas Gerais in Belo Horizonte was hosted by Fernanda Almeida, who specialises in reproductive physiology, and Dalton Fontes, who is a swine nutrition specialist. The quality of the research coming from the various universities in Brazil is very good and worth looking out for in the future.

I then travelled to Parana state which is a more traditional pig production area with about 0.5 million sows. I visited two pig producing co-ops, CAPAL and Copagril, which are fully integrated businesses, and met with their nutritionists and production managers.

Picture 4 : typical finishing pig buildings in Parana state, Brazil.
These solid floor buildings are washed down daily by hand as the slurry is used in an anaerobic digestion plant.

My final stop was to attend the annual Round Table for Responsible Soya (RTRS) meeting. The RTRS is a certification scheme for soya producers. The initial discussions began in London in 2004, with the RTRS being formally formed in 2006 and the first farms certified in 2011. In 2013, there were over 0.5 million hectares certified, producing about 1.2 million tonnes of soya beans.

5f. Netherlands

I ended my official Nuffield Farming visits with a trip to the Netherlands. I had been very impressed by the Topigs team (the Dutch based pig genetics business) I met in China. I had a link to their nutritionist, Willem Steyn who is based in the Netherlands and so organised a visit to Willem and a visit to a Topigs customer farm in the Netherlands. The Dutch are famous in the pig world for their utilisation of liquid feeds for pigs. I visited a company, Duynie, which trades liquid co-products of potato and wheat origin into the livestock sector. The potato by-products are derived from processing potatoes for human food such as chips. The wheat by-products are derived from the manufacture of biofuels and food grade starch production.

5g. UK

My UK visits are difficult to segregate from my day to day job, although one visit which I specifically organised as a Nuffield Farming visit was with Paul Featherstone, who is Procurement Director for SugarRich. SugarRich process and sell former human - foodstuffs such as biscuits, crisps and pasta - into livestock feed. In addition to his role within SugaRich, Paul is also Chairman of the recently formed European Former Foodstuff Processors Association (EFFPA) and he was able to give me an excellent overview of the former (human) foodstuffs market from a European perspective.

Picture 5 : Surrounded by chillies in Australia - this visit highlighted the water issue for me

5. Current feed ingredients

5a. UK

Typically, UK pig feed formulations include wheat, barley, wheat feed, biscuit meal, extracted soya bean meal (hipro), rapeseed meal, sunflower meal and synthetic amino acids. In addition, I estimate that about 15-20% of UK finishing pigs are fed some form of liquid co-products for example brewer's yeast, liquid whey, wheat distillers syrup. Table 2 shows some examples of typical formulations used currently in the UK.

Table 2: Typical UK pig formulations (based on July 2014 costs)

	% Inclusion					
	15-35kg	**35-65kg**	**65-110kg**	**Dry Sow**	**Lactating Sow**	**Average Inclusion**
Wheat	45.0	55.7	57.3	21.0	55.4	46.88
Barley	20.0	15.0	15.0	66.5	15.0	26.3
Wheat feed	-	-	6.6	5.8	-	6.2
Hipro Soya	25.0	17.8	6.5	-	16.3	16.4
Rape Meal	5.0	8.0	12.0	4.0	8.0	7.4
Lysine HCl	0.4	0.41	0.29	0.18	0.26	0.308
Threonine	0.15	0.15	0.065	0.04	0.06	0.093
Methionine	0.13	0.09	-	-	-	0.11
Soya Oil	2.5	1.1	0.5	0.5	2.7	1.46

The UK is self-sufficient in the production of cereals used for pig feeds and the biscuit/confectionary meal is also home produced. Over 50% of the grain produced in the UK ends up in animal feed, either directly or as co-products from other end users; for example, wheat feed from flour millers (HGCA). From a cost perspective, cereals account for about 63% of the diet and more than three quarters of the volume.

A large proportion of the protein in pig feeds is supplied in the form of soya bean meal, which is imported from both North and South America. We do use home grown rape seed meal, and in some instances home grown peas and beans, but the use of the latter two is fairly limited. The protein portion is also supplemented by using synthetic amino acids. The protein element of the diet accounts for about 32% of the total feed cost.

In the last 25 years, there have been some key changes in the ingredients used in UK formulations. Products such as fishmeal have reduced due to price and availability and only feature now in piglet feeds. Meat and bone meal was banned in 1996 in all farmed livestock feeds. Vegetable protein sources such as rape seed meal and sunflower meal have increased in usage. Selective breeding of rapeseed to reduce glucosinolates (anti-nutritional factors) have allowed an increase in its use. Improved processing techniques in sunflower have created a higher protein product which is more valuable in both nutritional and economic terms. In addition, improvements in the way we quantify the nutritional value of these products have allowed for more effective use of these types of ingredients, for example, the introduction of using "Net" rather than "Digestible" energy. The price of synthetic amino acids has decreased making them better value for money. This means that

synthetic lysine, methionine and threonine, are commonly used across all diets, with tryptophan and valine being used in piglet feeds. Products such as biscuit meal/bakery waste are more widely used due to better quality control and processing, resulting in a much more consistent quality product.

Finally, from an ingredient perspective there is much wider use of fibre digesting and phytase enzymes which both enhance the utilisation of components naturally present in ingredients, reducing nutritional pollutants such as phosphorus.

6b. Canada

Canada uses maize and soya based diets in the east and wheat, barley, wheat feed and soya based diets in the west. I visited a farm in Ontario (eastern Canada) which is utilising liquid co-products such as whey and brewer's yeast. A lot of the Canadian wet feeders use a feed base of home grown high moisture ensiled maize. I have seen this ingredient in other parts of Europe but rarely in the UK. About 25% of the pigs in Ontario are liquid fed and this is possible because of the proximity to Toronto, meaning a supply of human food based co-products.

Picture 6 : Canadian pigs eating a diet which is based on high moisture ensiled maize and mixed with liquid co-products.

Canada is self-sufficient in the ingredients it uses for pig production. Canada makes use of large volumes of canola (rape) seed meal and has been instrumental in developing the low glucosinolate varieties; it has carried out extensive research into the use of rape seed meals in pigs and poultry. Much of the research has focussed on the processing of rapeseed meal as this has a significant impact on quality/digestibility. The Canadians also grow significant quantities of pulses – peas, faba beans, navy beans etc and these are often available to use in pig feeds when the prices are favourable.

6c. China

Chinese pigs are predominantly feed on maize and soya based diets and there is some use of wheat and wheat feed. The Chinese government took a decision in 1995 to focus on becoming self-sufficient in terms of grain production, whilst being reliant on the import of proteins such as soya bean meal. China imports two thirds of global soya production. They are also importing DDGS from the USA as an additional protein source.

China imports two thirds of global soya production.

6d. Australia

In Australia, pig diets are similar to those of the UK in their use of home grown wheat, barley plus oats, rye and triticale, and wheat feed, all coupled with imported soya. As an additional protein source, they use inclusions of lupins (*Lupinus angustifolius),* up to 35% in finisher diets. These grow well in Australia and have been selectively bred to reduce the anti-nutritional factors commonly associated with lupins. Surprisingly, the Australians are also using meat and bone meal. Canola expeller meal and sunflower meal are also both available. Whilst liquid feed units do exist, the use of liquid co-products is not overly common in Australia.

6e. Brazil

As would be expected, Brazilian pig feeds are predominantly based on home produced maize and soya. As in Australia, there is some use of meat and bone meal although, due to cost, inclusion rates are low (2-3%) and used as a phosphorus source rather than solely a protein source.

6f. Netherlands

In Europe, the Netherlands is a central point for the importation of a very wide range of feed ingredients. Therefore, Dutch pig diets use a very wide range of ingredients, although soya is still a key feature of feeds, as it is in the rest of Europe. In addition, the Dutch make good use of liquid co-products such as potato by-products and wheat distillers syrups.

6. Focus on soya

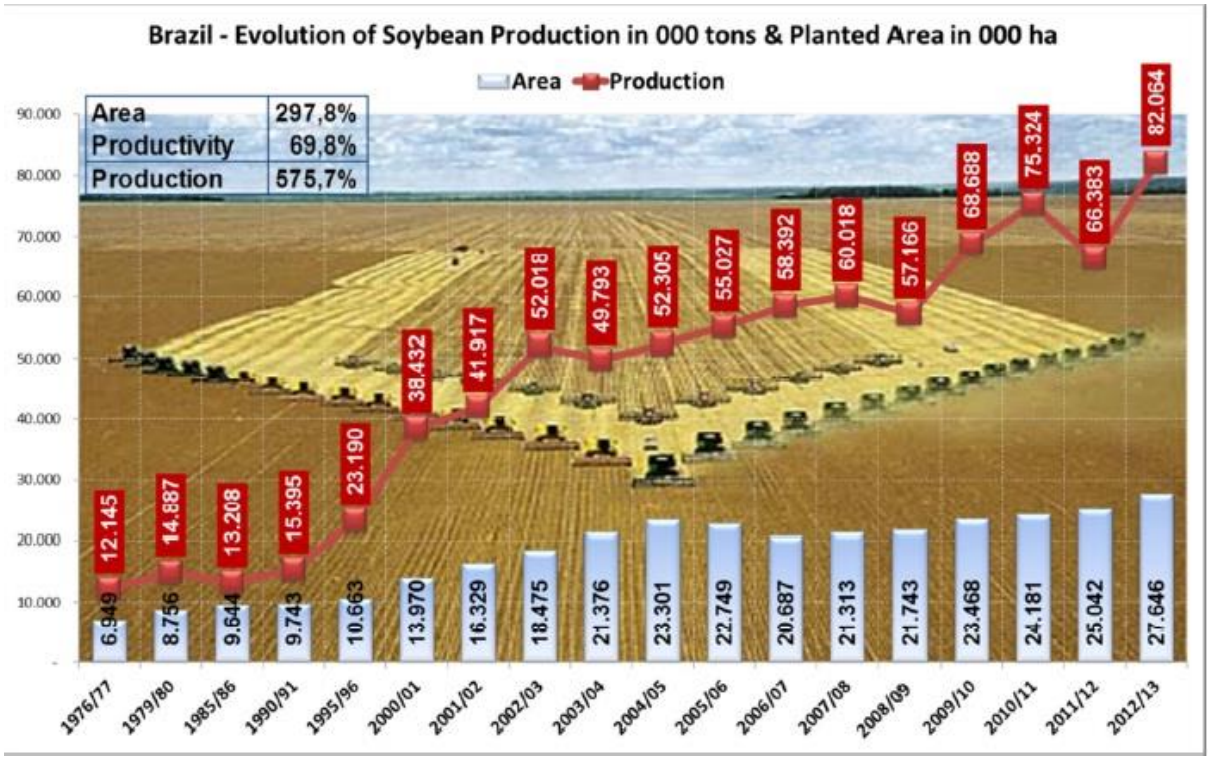
Globally, there are 253 million tonnes of soya beans produced, which accounts for 2.2% of global agricultural land use (*FAO, 2013 via Retailers Soy Group*). Approximately 70% of soya produced is destined for animal feed and the remainder for human food and biofuels. With regards to volume, the use of soya bean meal in animal feed is split into 50% for poultry and 25% each for pigs and cattle. Production takes place in North and South America, Asia (including China and India) and now in Europe too.

… the use of soya bean meal in animal feed is split into 50% for poultry and 25% each for pigs and cattle.

Soya beans typically consist of 20% fat/oil and 36% protein. The oil is removed by a variety of methods although most typically by solvent extraction. The remaining soya bean meal contains ~ 44-48% protein and 1-2% oil. The method of processing determines the nutritional profile and the quality of the remaining meal. As a rule of thumb, 100% of soya beans yields 73% soya bean meal (48% crude protein content) with an estimated 33kg of soya bean meal being used per pig produced.

6a. Brazilian soya

Brazil has been the focus of much attention in recent years in relation to its soya production which has been growing rapidly. Brazil has recently become the largest global producer of soya beans with the USA as the second largest. These two areas are responsible for more than 60% of global soya bean production. The chart below illustrates how the Brazilian growth has come in part from increased area planted but also from a large increase in productivity.



Picture 7 : development of Soya production in Brazil (from an article by Brazilian consultant Osler Desouzart: "Do not disturb me with data & facts since I have already made up my mind").

In Europe, in the popular media, it is common to attribute the loss of the Amazon rainforest to the cultivation of monocultures of soya and corn. Interestingly, 48% of the Brazilian soya crop is produced in the Central West region and 29% in the South and only 3% in the North where the Amazon region lies. Under a Brazilian Forestry Code, originally created in the 1960s but transformed in the 1990s, 20% of a farm has to exist as native vegetation. Part of the legislation is to designate areas which are environmentally sensitive as APPs - Areas of Permanent Preservation - which aim to prevent soil erosion and conserve water resources. Brazil appears to have been very successful in reducing deforestation and implementing a process of reforestation of illegally deforested land. In 2012 a new Forest Code was passed which has still not yet had the absolute details of implementation finalised. Some groups say it is too lenient on land owners and will allow an increase in deforestation although, conflictingly, other opinion suggests it will be a barrier to agricultural development. In addition to discussions about the Amazon rainforest, the impact of soya production in other areas of Brazil is also under discussion; for example the Cerrado Savanah. This is a massive topic which warrants its own discussion. However, having attended the RTRS meeting, I know there is a great deal of good work going on to ensure there is a balance between conservation and food production. The same can be said for the US, as I heard a similar message from the US Soya Export Council.

Brazil appears to have been very successful in reducing deforestation and implementing a process of reforestation of illegally deforested land.

7b. Soya sustainability protocols

As previously stated, soya is produced not just in North and South America, but also in Asia and Europe. In sustainability terms, there are different environmental pressures in each of the different areas. There are also a variety of different perspectives in terms of sustainability and approximately 40 different production standards which growers can potentially work to.

At the RTRS[1] meeting I met a representative from the Retailers Soya Group (RSG). The RSG represent a significant number of the UK and European retailers and has set a minimum production standard for soya, regardless of its country of origin, for both feed and food use. In a position paper given out at the RTRS meeting they state:

> *"The RSG does not believe that the growth in demand for soya has led to destruction of primary and native forests, loss of biodiversity and other issues associated with soya cultivation. We believe that better management of land use change, combined with maximising productivity, offers an opportunity to reconcile growing demand for soya with the need to conserve the most valuable landscapes."*

The RTRS and ProTerra are two standards that comply with the RSG minimum standards. They are planning to commission the International Trade Centre Standards Map to conduct independent benchmarking of soya standards against their minimum requirements, to identify whether other internationally applicable standards may be recognised as they develop.

[1] Round Table for Responsible Soya

FEFAC (European Feed Manufacturers Association) are in discussions with groups such as USSEC and RTRS to try to create a level playing field so that ingredient buyers are not overwhelmed by the number of sustainability schemes that are out there, and at the same time be certain that the products they are buying and trading are sourced to a suitable standard.

7c. Biotechnology

I didn't focus on biotechnology (genetic modification) during my study but think it is important to mention briefly. Biotechnology in soya seed stock use has increased dramatically in all the main soya producing countries, as illustrated in the table below. Thomas Miekle began his presentation at the USSEC meeting in Turkey with the words *"It's over – we don't have an option on GMO or non GMO".* This sentiment was echoed by John Baize who commented that the US soya growers used to listen/react to the European demands regarding biotechnology, but this is no longer the case as Europe is not a key player in the market any more. Finally, a nutritionist in Brazil commented *"We have no choice on GM – the seeds are here and here to stay".*

" … we don't have an option on GMO or non GMO". ….. US soya growers used to listen/react to the European demands regarding biotechnology, but this is no longer the case as Europe is not a key player in the (soya) market any more

Table 3 Adoption of Biotech-Enhanced Seedstock (adapted from SoyFacts 2013, American Soybean Association).

Year	United States	Argentina	Brazil
		Percentage Biotech	
1997	12.7	22.9	2.0
2000	54.9	94.8	24.0
2003	81.0	99.1	34.0
2006	89.0	99.5	56.0
2009	91.0	98.9	70.7
2012	94.0	100.0	89.0

7d. Wastage

During the USSEC conference in Turkey, the presentation of market analyst John Baize suggested there are 30% losses of soya (and no doubt the same is true for grain) in the developed world before the material reaches the animal feed stage. This is wastage during harvest, in transport, storage, processing etc. I really didn't believe that this figure could be true until I visited Brazil. I have followed lorries carrying soya which continuously "leak" beans that bounce off your

… since 1990, there has been a 459% increase in soya volume from only a 66% increase in planted area and yet these increases have not been matched by infrastructure investments

windscreen, and it made me realise that this 30% figure is probably true; especially when you consider that soya is transported 2000km from Mato Grosso to the port by road! John Baize also stated that, based on yield and acreage *"total protein production is currently above demand".*

At the RTRS conference in Brazil, soya bean wastage was also highlighted by speaker Jefferson Carvalho of Rabobank Brazil. He stated that since 1990, there has been a 459% increase in soya volume from only a 66% increase in planted area and yet these increases have not been matched by infrastructure investments. The lack of logistics is destroying the value of the grain and also causing huge losses. Carvalho talked about a loss of 10.2 million tonnes of soya and gave a few facts of what this equates to:

- 10.2 million tonnes requires a land mass the size of Belgium to produce it.
- 10.2 million tonnes can feed the population of France
- 10.2 million tonnes requires the same amount of water needed by 170-340,000 people
- 10.2 million tonnes equates to 5.5-5.6 billion dollars (£3.2 billion)

To put these figures into a pig context, 10.2 million tonnes of soya beans would produce enough hipro soya to produce 227 million pigs, based on 73% yield of hipro soya from soya beans and 32.8kg of hipro soya used per pig, in typical UK formulations. The waste is sufficient to feed one third of China's annual slaughter pig production. These figures are quite frightening.

The waste is sufficient to feed one third of China's annual slaughter pig production.

In Brazil, there is currently insufficient dry storage during harvest, which means that large volumes of product are stored outside once the silos are full. This is shown in the picture from Carvalho's presentation.

Picture 8 : Outside grain storage next to full silos (from Carvalho, Rabobank RTRS Presentation)

However, Carvalho did state that the Brazilian Government has released 25 billion reals (£6.6 billion), 5 billion per annum for the next 5 years, for producers to invest in storage, which will have a big impact on reducing losses. During my visit I certainly saw investment in more storage. One of the co-ops we talked to were in the process of doubling their storage capacity and another said they plan to increase the amount of grain they can store for their feed operation by 300%.

Picture 9 : Coavril building grain silos which will double their storage capacity for the next harvest.

There also needs to be greater investment in other areas of the infrastructure, for example road links, in order to keep pace with the developments in production output. According to John Baize, in May 2013, there was a 65 day waiting time for trucks to load ships at the ports in Brazil and a line 90km long of trucks waiting to enter the port.

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7. Alternative ingredients

7a. Alternative vegetable protein sources in the UK

The pig has good capacity for utilising a wide range of alternative vegetable protein sources. This has been shown with the more recent use of rape seed meal and sunflower meal. Ingredients such as peas and beans also show good potential. A collaborative UK project known as "Green Pig" showed that the use of high levels of peas and beans in diets is possible. These results supported those of earlier studies by Canadian researchers. Whilst we know we can use peas or beans, there simply aren't enough grown in the UK due to issues with agronomy and lack of economic return for the grower. Products such as lupins might also be interesting in the future but they have similar drawbacks to peas and beans. This situation is changing slowly with new varieties being brought in and increasing interest in home grown proteins.

I have heard and read that soya is being grown in the UK. This may be a possible option for some growers in the future as part of arable rotations. It seems, on paper, that yields can match those of product grown in the US and South America and there is work being done to improve the varieties to suit the UK climate. Figures of up to 2.5 tonnes/hectare are suggested as possible for the UK *(www.soya-uk.com*) although yield estimates vary, with quoted yields of between 0.74 up to 3.1 tonnes/hectare *(Farmers Weekly article, 30/12/2010*). As a comparison, the USDA figures for the US in 2012 were 2.6 tonnes/hectare, and the predicted 2014 Brazilian yield was 3.05 tonnes/hectare.

If home produced soya does become more widespread we need to ensure we understand the nutritional specification, as this is likely to differ to the product grown in the Americas. From a sustainability perspective we should be certain that growing soya in the UK is the most sensible use of the land. Soya production would be in direct competition with other crops and resource and this is an area the experts in arable production need to evaluate carefully.

Scientists from Wageningen University in the Netherlands, along with Plant Research International and Food and Biobased Research, published a very good report in February 2013 called "Cultivation, processing & nutritional aspects for pigs and poultry of European protein sources as alternatives for imported soya bean products". This study put together a long list of 62 feed ingredients which contained a wide range of protein sources. It then created a shortlist of potential proteins that may contribute to increased protein production in Europe, which is shown in Table 4 below. In creating this shortlist they looked at factors such as; whether the protein source would be able to perform well in the climatic conditions of North West Europe; whether cultivation of the product was already commonplace in Europe; and whether in the long term (beyond 2020) the protein source will still be available for feed or is the use limited to food applications.

Table 4 Shortlist of potentially interesting protein sources to increase EU feed protein production

Category	Protein Source
Oil Seeds	Proteins of Deffated Soya Beans, rape seed and sunflower
Grain Legumes	Peas, *Vicia Faba*, lupins and their concentrates, chick peas
Forage Legumes	Lucerne (alfalfa)
Leaf Proteins	Grass, Sugar beet leaves
Aquatic Proteins	Algae, both macro- (seaweed) and microalgae, duckweed
Cereals and pseudo cereals	Proteins from oats and quinoa
Insects	e.g. meal worm, housefly and cricket

Source for above table: Wageningen UR 2013 "Cultivation, processing & nutritional aspects for pigs and poultry of European protein sources as alternatives for imported soya bean products"

7b. Co-products

The co-product market is constantly changing. It is often the early adopters that gain the most from these types of products but obviously this does come with some risks.

Dry co-products such as wheat feed (the by-product of flour milling which is also known by a number of different names such as mill-run, pollards, middlings etc) have been used in animal feeds for a long time and are well understood. Products such as DDGS[2] have become more available in recent years with the increase in production of bioethanol from cereal grains. Both maize- and wheat-based DDGS are common and are suitable for use in pig diets. However, in the UK market they tend to be used in ruminant feeds, as they are worth more in this sector. DDGS are a very good example of how co-products evolve and change. In the past this product had a relatively high oil content, but processing techniques do now allow this to be extracted for use as fuel, which reduces the value of DDGS in diets. It is also highly variable in terms of nutritional quality depending on the source, due to processing factors.

As with dry co-products, the liquid co-product market is also constantly changing. Liquid whey, which is a co-product of cheese production, was traditionally a very good quality and widely available ingredient for pig feed. In recent years, the availability in the UK market has decreased. This is due to the development of processing techniques which allow the whey to be dried for baby milks or further processed to extract other high value components such as whey protein and lactose. We now see wider availability of whey permeate which is basically "stripped down" whey, but this is of much reduced value compared to whey.

(whey) was traditionally a very good quality and widely available ingredient for pig feed. In recent years, the availability in the UK market has decreased

7c. Former foodstuffs

It is estimated that there are approximately 7.5-8 million tonnes of former food products in the EU-28 and currently about 55% of this volume is thought to be reused as animal feed.

Of the volume that is not currently captured, there are some "low hanging fruit" that need some changes in legislation to allow more use of products. For example, in Europe there is a large volume of former food products which cannot be used due to the presence of bovine gelatine. In the UK alone, it is estimated that there are 15,000 tonnes of waste confectionary products that contain bovine gelatine and a further 75 to 100,000 tonnes in Europe. In addition, in the distribution and retail sections of the food chain, there are more products which could be captured. This would help towards the European 2020 goal of a 50% reduction in products going into landfill. It is areas such as these that EFFPA will work on to ensure that, where legislation changes occur, both feed and food safety is at the forefront. EFFPA is also in dialogue with the British Retail Consortium regarding their

[2] Distillers' Dried Grains with Solubles

standards for dealing with former food products. Again, this will help to capture greater volumes of products safely and efficiently.

Picture 10 : visiting the former foods processing site of Progressive Recycling in Canada

The feeding of "swill" has come up in discussion in the UK in 2012/2013 because environmental campaigners want the pig industry to reduce soya reliance and to use the pig to "recycle food waste". Swill was banned in the UK on the back of the 2001 Foot and Mouth Disease (FMD) outbreak which had a devastating impact on UK livestock production. The ban was also implemented throughout Europe. In Canada and Australia, swill feeding was banned following FMD in the UK and this ban has remained in place. In China, swill is thought to be used; however it appears that this is only in the "backyard" situation and the commercial pig herds have recognised that hygiene and consistency are an issue. I believe that the restaurant and catering trade need to look at reducing their food waste first, rather than thinking the pig industry can clean up their problem. If swill were to come back in, it would require central processing plants and need to be carefully monitored, which would add cost and may make the product uneconomic. The variability in the nutritional specification would also limit the use. Whilst soya bean meal does exhibit a certain degree of variation, it is actually an extremely consistent product which makes it ideal for ensuring consistent pig performance.

7d. PAP, algae, yeasts and insects

Other ingredients that may be possibilities for the future include PAP (processed animal protein or what used to be known as meat and bone meal), algae, yeasts and insects amongst others. I have not studied these in any detail during my travels but they may have potential for the future.

PAP is currently used in the pet food industry and has reached a price point which, even if legislation changed to allow it back into pig diets, would mean it is too expensive. The issue of consumer acceptability would also need to be overcome.

Products such as algae and yeasts also have good potential; however, the key for these is developing suitable technology for extraction and drying, which is both efficient and environmentally sustainable.

Insects are also attracting a lot of attention and there are various projects and commercial ventures that are developing large scale production of insect protein; for example, meal worms and housefly maggots. Wageningen University has published a very good report which is linked to the Alternative Proteins report mentioned previously - "Insects as a sustainable feed ingredient in pig and poultry diets – a feasibility study" (October 2012). The conclusion of this report is that the feeding of insects to pigs and poultry is technically feasible. It comments that the first likely use would be in aquaculture, rather than pigs and poultry, as an alternative to fishmeal. It is currently estimated that insect meal will be 10-15% cheaper than fishmeal. The Wagneningen report also summarises *"For pig and poultry use, there is a need for further research relating to the feeding value, inclusion rates, functional properties, safety when using bio-waste as a rearing substrate, extraction of nutrients, shelf-life and left over substrates and residues of insects".*

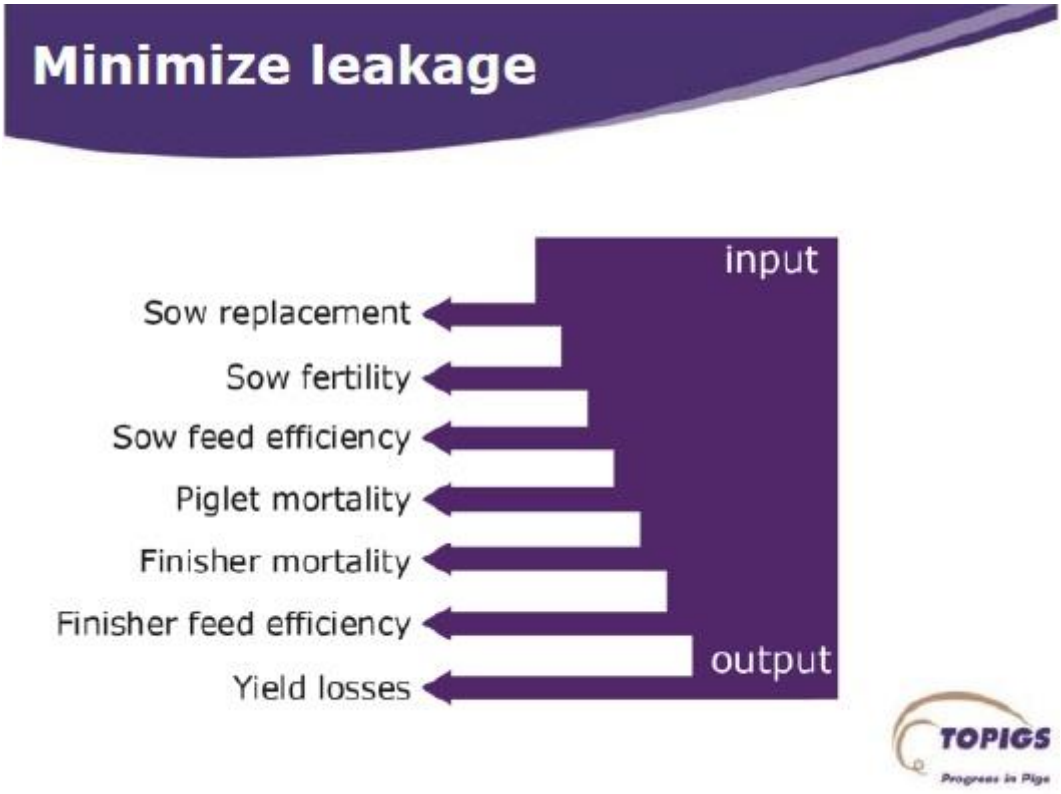
Insects are actually already consumed widely by humans and are part of the diet of 2 billion people Worldwide (Mick Hazzledine, BPEX Innovation conference, 2014).

Picture 11 : Silk worm larvae served in a restaurant I visited during a business trip to South Korea.

8. Efficiency (minimising wastage) in pig production

There are definitely opportunities for alternative feed ingredients, yet there are big opportunities for making better use of the feed resources we currently have i.e. improving efficiency and minimising wastage within the pig production cycle.

Topigs have two very valuable concepts when talking about efficiency in pig production. The first that they use regularly in presentations is the idea of "minimising leakage". This means reducing losses at the different stages of production whilst maximising output. This concept takes into account sow replacement rate right through to yield/carcass losses at the slaughter house.



Picture 12 : the Topigs concept of "Minimising Leakage" in pig production to maximise output.

Topigs also use the concept of Total Feed Efficiency. Traditionally in pig production we only talk about feed conversion ratio (FCR) or feed conversion efficiency for slaughter pigs and often only look at this between weaning and slaughter, or 35kg and slaughter. The Topigs concept aims to manage their genetic development programme to optimise feed efficiency across the whole herd, and includes sow productivity in this equation. This means including factors such as sow feed consumption and piglet output to give a complete "farrow to finish" efficiency measure.

There is an online calculator which producers can access to asses efficiency in their own herd - http://www.totalfeedefficiency.com/.

In order to improve herd efficiency there are a number of areas that can be looked at which involve inputs from different areas of the supply chain:

8a. Genetic input

Genetic progress is occurring at a very fast rate. During my visit to Topigs, I learnt that the top 10% of boars in their nucleus units are capable of growing at an average of 1200g/day, between 30 and 120kg live weight with an FCR of 1.8. Other breeding companies around the world are likely to be producing breeding stock with similar capabilities. This performance is considerably ahead of the current UK performance of 842g/day between 35-110kg with an FCR of 2.41 (BPEX Top 10% of producers, July 2014). These pigs will be available in the commercial environment in approximately three years' time and so this future level of performance is going to require a much better understanding of the nutrient requirements of these pigs in order to capture this superior performance. With these growth rates and improved feed conversion, utilisation of ingredients can potentially be much improved.

In addition to improving growth performance of finishing pigs, genetics businesses are also focusing on producing sows which have the ability to rear large numbers of viable robust piglets. The more piglets each sow can rear helps to improve the total herd feed efficiency, and a focus on robust healthy pigs means there are fewer losses during the production cycle. Losing pigs to ill health, which have already consumed considerable amounts of feed, is not only costly for the producer but also wastes valuable feed resources.

8b. Nutritionist input

In the last 25 years we have changed the nutrient parameters with which we formulate, which means more precision in nutrition can be applied. Net energy is now widely adopted, as are digestible amino acids and digestible phosphorus. This means diets can be more closely matched to pig requirements, potentially reducing the amount of nutrients which are wasted and excreted and reducing the risk of undersupplying nutrients so the pig cannot exhibit its full growth potential.

In order to really capitalise on this enhanced knowledge we need to work with producers to provide data on criteria such as feed intakes. If we know what individual feed intake is on farm we can build less "insurance" into specifications, which ultimately means better use of nutritional resources. For example, we know that for each kg of growth, a pig requires around 22g of SID (Standardised Ileal Digestible) Lysine. If a pig consumes 2.5kg/day of a 0.85% SID Lysine (8.5g/kg) then it is consuming 21.25g SID Lysine per day which is sufficient to gain 966g/day. If that pig only consumes 2.2kg of the same feed per day, it is only consuming sufficient for 850g/day of growth. In order to bring this pig back up to the same growth rate of the first example, we need to increase the diet density to 0.966% SID Lysine.

In the UK, it is still relatively common to use just one or two different specification diets between 30/35kg and slaughter. The issue with this is that for a large proportion of the time nutrients are either under or over supplied, which has a knock on effect on performance and efficiency. In Brazil, I found it was common to feed up to 5 or 6 diets between 30kg and slaughter. This is possible because of the scale of some of the units. For example one whole building is filled with a complete batch of boars or gilts on the same day, at the same age and fed from its own feed line, meaning that each feed delivery can be a specification which is tailored to the live weight of the pigs. On smaller scale units, there is still an abundance of relatively cheap labour. Pigs are often hand fed, allowing more feed changes as feed lines are not a limiting factor. This situation is changing as

labour becomes more of an issue but this is likely to be countered by units increasing in size and therefore increasing automation.

Picture 13 : Finishing pig buildings in Brazil, one for boars and one for gilts with individual feed bins and lines per building which allows for more diet changes through the growth period.

Whilst the situation in Brazil is preferable to the two diets used in the UK, it is still not a perfect solution. Automated feeding systems, which have the capability to blend diets so that the use of true phase feeding is possible, should become more prevalent over time, thus matching the pig's daily nutrient requirement with their potential growth. These types of systems are a great improvement on only feeding one or two feeds; but they are still based on selecting a nutrient specification which is relevant to one pig and not the entire group or population. From an economic perspective, guidelines suggest that we aim to provide 85% of the population with sufficient nutrients to match genetic potential. In reality, even with good farm data, this means that 14% of the pigs in a pen are growing sub-optimally and 84% of the group are being over supplied, meaning wasted nutrients.

In order to overcome this there is some interesting work being carried out by Dr Candido Pomar in Canada. He and his team are looking at technologies to feed pigs individually, with diets adjusted daily to match their requirements according to their growth curve. The system has been successful in research conditions and has resulted in improved nutrient efficiency; reduced nutrient excretion, for example nitrogen; and improved economics through reduced feed costs. This is potentially exciting technology for the future.

8c. Feed production input

Feed form plays a role in improving efficiency. It has been well established that pelleted feeds can improve feed conversion ratio and average daily gain. A summary of research trials complied by Kansas State University (2013) showed an average improvement of 5.1% in FCR and 4.4% in average daily gain. The main reason for this improvement is reduced dustiness and wastage although particle size, and a pelleting effect, may exist which adds to the improvement. The caveat with this is that the pellets must be good quality. A poor quality pellet is typically no better than meal in FCR terms.

Whilst in Canada, I heard about a grain sorting system, the BoMill TriQ system (www.bomill.com) which can be applied in feed mills. The University of Saskatchewan has installed one of these systems in their research feed mill and it is already being used commercially in the food industry, for example in a pasta plant in Italy. The Bomill system takes 18 images (6 replicates of 3 parameters) of each grain and can sort product according to vitreousness, protein content or fusarium contamination. Each BoMill unit can process 30,000 grains/second and the units can be stacked to increase capacity. The estimated cost for installation and operating of the equipment is $10/tonne. A sorting system such as this offers great potential for sorting grain by nutritional parameters which would allow further precision in feed manufacture.

8d. Farm inputs

Whilst I have been travelling for my Nuffield Farming Scholarship, a horrendous disease called PEDv (Porcine Epidemic Diarrhoea Virus) has caused huge losses of piglets in the US pig industry. It has also affected some areas of the Canadian pig industry and, having been present in Asia for a number of years, is a continuing problem. Management of strict biosecurity protocols is essential to ensure that diseases such as PEDv do not have the opportunity to cause such devastation.

PEDv is an extreme disease that causes high levels of mortality. However, even at a less severe level, we know that disease challenge has a negative impact on pig performance efficiency. From a nutritional perspective we are learning to understand the impact of disease on performance and nutrient requirements. Recently published work by Evonik provides data on the need for increased methionine relative to lysine, in pigs undergoing a health challenge, to maintain performance. The area of nutrient requirements under disease pressure still needs further research work to reduce the impact, but the bottom line is that management to ensure health should be the primary target.

Feed wastage on farm is another area where a large improvement can often be made. Adjusting feeders to ensure the correct flow rate for the age of pig is essential to minimising wastage. Estimates start at 5-10% of the total usage, for the waste of valuable feed due to poor adjustment. Checking for leakage along the feed lines and from the feed bins is also an area to focus on.

9. Water in pig production

During my travels water was routinely discussed as a finite resource. I believe that the supply of water, not just for livestock production, will become of primary concern in the future. This was really highlighted during some of my Australian visits and also by an update from a fellow Australian Nuffield Farming Scholar who told us he is now selling water, as this is more profitable than using it to irrigate his crops.

… a fellow Australian Nuffield Farming Scholar … told us he is now selling water, as this is more profitable than using it to irrigate his crops.

In the UK I rarely go to slaughter houses to see the end of the production cycle, but an opportunity arose in Brazil to visit the slaughter house of Nutribras. The slaughter house was newly built in 2011 and is based on a design the owners had seen on a visit to Spain. What caught my attention was the volume of water that is used in the slaughter process and then during the clean down of the plant every day. 480 litres of water are used to process each pig they slaughter and they are currently slaughtering 1200 pigs per day. I have subsequently read that a Danish slaughter house has managed to reduce the quantity of water used per pig slaughtered to 170 litres and is working on reducing this further to 150/160 litres.

480 litres of water are used to process each pig they slaughter and they are currently slaughtering 1200 pigs per day

When I first arrived in Brazil I thought that water supply was not an issue for them. I was told that in the Mato Grosso region annual rainfall can be as much as 2500mm. However, as I continued to travel through Brazil I discovered that the population density in cities such as Sao Paulo is putting pressure on the natural water reserves. From a food production perspective, one of the Brazilian co-ops I visited was planning a new slaughter house; the availability of a good water source is one of the key factors they are looking at. This is one of the main determinants of where the facility will be located and a system to clean and recycle the water will also be incorporated.

This highlights that water supply is becoming more of a focus, even in a country which appears to have no shortage of water.

10. Discussion

At a recent BPEX Innovation conference, Andrew Knowles, during his introductory presentation, used a quotation from David Brailsford, the former Performance Director for British Cycling and current General Manager of Team Sky: *"Small improvements in a number of different aspects of what we do can have a huge impact on overall performance."*

Brailsford famously talks about the "aggregation of marginal gains" as the key to the success of the British Cycling team at the London 2012 Olympics. He explains this concept as follows:

> *"It means taking the 1% from everything you do; finding 1% margin for improvement in everything you do. That's what we do from the mechanics upwards. Naturally all these tiny gains can add up to a large gain – potentially race winning or record winning"* or, in agricultural terms, meeting the challenge of feeding 9 billion people by 2050.

Andrew Knowles's idea of applying this sort of principal to pig production seems to me to be a very sensible approach and is one that can be applied to all areas of agriculture.

Globally, if the soya growers can focus on reducing wastage by 1%, that means an extra 2.53 million tonnes of soya becomes available. 2.53 million tonnes is sufficient to feed another 77 million pigs, or 2 years of Brazil's current number of slaughter pigs. The same principle can be applied to UK grain production and within feed mills, to reduce wastage of ingredients.

An area where pig producers can have an impact is to focus on improving FCR. Table 5 illustrates the effect of three levels of feed conversion ratio on the consumption of soya bean meal.

Table 5 Comparison of soya bean meal usage based on differences in Feed Conversion Ratio (FCR)

	BPEX Top 10%	BPEX Top Third	BPEX Average
FCR	2.41	2.59	2.8
Feed Used 35-110kg (kg/pig)[1]	180.75	194.25	210
Soya Used (kg/pig)[2]	21.96	23.60	25.52
Extra Soya per 1000 pigs produced (kg)	-	1640	3560
% increase in soya use[3]	-	+7.5%	+16.2%

Based on BPEX July 2014 data. [1] Assumes no difference in feed specification; [2]Average inclusion rate of soya bean meal 12.15%; [3] Compared to Top 10% of Producers

If the average producers were able to shift all their production up to an equivalent FCR of the top third category, this has the potential to save 13,000 tonnes of soya per annum (based on 6.798 million pigs and 1.92kg soya saved per pig).

All the above calculations are based on live weight FCR; however, it is being suggested more widely that we should really be reviewing performance on a dead or carcass weight FCR. Most pigs are sold on a carcass weight basis and generally carcass weights are reported by the abattoir on the grading sheets which are returned to the producer. In order to look at live weights, these need to be calculated from the dead weight, or pigs need to be weighed on departure from the farm. Extra

recording on farm is often met with resistance so making use of the information already at hand is a sensible option. The other record which is always provided is the volume of feed delivered or, in the instance of home mixers, a record of quantities produced, which is required for meeting legislative requirements. Therefore, applying the feed delivery notes/on farm manufacture records as the basis of feed used, and the grading sheet carcass weight data for the output of the ratio, a true and more useful total herd FCR can be calculated.

These are just a couple of examples of where improvements in efficiency and reduction in wastage can occur. At each stage in the production of pigmeat - from soil management for the growing of ingredients to slaughter house processes - if each element is reviewed and improved by a small amount, there is potential for significant gains.

I believe that sustainability is about improving efficiency. We can reduce wastage through the implementation of knowledge, better management and technological advances. If we improve efficiency we can have a very positive impact on sustainability.

Sustainability should not mean reduced profitability or a return to the "good old days", which many consumers dream about. On the basis of the many different things I've seen during my Nuffield Farming Scholarship study tour I believe that sustainability is about improving efficiency. We can reduce wastage through the implementation of knowledge, better management and technological advances. If we improve efficiency we can have a very positive impact on sustainability.

Picture 14 : An example of potential technology for the future - the individual feeders developed by Dr Candido Pomer to feed pigs according to nutrient requirements (BPEX Innovation Conference presentation).

11. Conclusions

- Soya will remain the dominant protein source for pigs for the foreseeable future.
- Soya growers are endeavouring to improve their environmental impact.
- Alternative ingredients do exist but face the same challenges in terms of availability of land, water and nutrient inputs as conventional raw materials.
- Feed and food safety are critical when considering alternatives.
- Waste reduction throughout the food chain from farm to fork is essential.

12. Recommendations

1. As users of soya we need to support the efforts of growers to improve their environmental impact, which will encourage more growers to follow suit.
2. As alternative ingredients become available, we need to ensure we have a thorough understanding of their nutrient profile so they can be used to the best effect. Growers of these alternatives need to be certain that they really are sustainable alternatives. We need to ensure that the most suitable product is produced in the most appropriate environment.
3. Changes in legislation need to occur to allow more use of former foodstuffs; however feed and food safety must not be compromised.
4. Everyone involved in pig production needs to focus on making small improvements in all the things they do, which has the potential to have a big impact on overall efficiency and performance.

13. After my study tour

Working in the allied industry means that I cannot directly make changes on farm to the sustainability of pig production; however, I can advise, guide and assist. Through my formulations I can strive to work with my customers to aim for a "more for less" target. My work has always included elements of working with producers and, from a feed production perspective, to improve efficiency. Undertaking a Nuffield Farming Scholarship has really helped my focus in my work and I am even more determined to ensure that I have a positive impact on future production. I have dates in the diary for speaking at various pig discussion group meetings in Nov 2014 and early 2015, which I hope will bring benefit to the pig producers and allied industry members who attend.

Nuffield Farming has brought me much more awareness of other areas of agriculture. I am from a non-farming background and although I've learnt a lot during 15 years as a pig nutritionist, the Nuffield Farming process has accelerated my knowledge considerably. Two years ago I had never heard of things like "controlled traffic farming" and "minimum till practices". A really valuable aspect is that I have a far better understanding of crop production than I did before, which is of great help for understanding the ingredients we use in pig production.

During my travels I have seen how important innovative, forward thinking people are for the future of UK agriculture. I am lined up to become a Bright Crop Ambassador to try to encourage people to join our industry. I have also already provided some training sessions with students who are considering coming into agriculture.

Alongside a colleague at Premier Nutrition, I have helped to provide a school in Leeds with some resources for teaching Year 7 students about food and food production. Before my Nuffield Farming Scholarship, I was not aware of all the work that groups such as the NFU, FACE, LEAF etc. do in providing these types of fantastic resources. In September 2014, we will partake in some teaching sessions with the school.

I have always been a strong advocate of recycling within my own home and make fantastic compost from my garden and kitchen waste with my wormery. In addition, as Lisa Rausch, whom I met in Brazil, put it *"I treat food as though I was raised in the Great Depression".* Having discovered more about the volume of waste that exists in the food chain, I have decided that I need to help other people learn how to make use of their food waste by turning it into compost. I have found out about a programme called Rotters which is part of the "Love Food Hate Waste" campaign. Rotters are a team of volunteers who attend local events to encourage and guide people on how to reduce their food waste and compost the unavoidable wastes. It is my intention to become a Rotters volunteer, now that the official Nuffield Farming process is complete.

Michelle Sprent

14. Executive Summary

The human population is predicted to reach 9 billion by 2050, which will mean 2 billion more mouths to feed compared to 2013. In addition to this, in the developing world - as countries become more affluent - there is greater demand for animal protein. Globally pigmeat contributes 36% of total meat consumed which equates to an average 15.8kg of pigmeat consumption per capita per annum.

Feed costs can account for up to 70% of the cost of pig production. In recent years the key ingredients used in UK pig diets i.e. cereals and soya, have experienced increasing price volatility. These products are now traded globally and are therefore heavily influenced by global economics and demands. This can have a dramatic effect on the profitability of pig production.

Greater demand for pigmeat means that larger quantities of feed ingredients are needed. These need to be cost effective to ensure profitability in pig production. However, they also have to be produced from a finite amount of resource - land, water and nutrient inputs - to minimise environmental impact whilst maximising output.

The primary goal of my study was to review the ingredients being used in other countries and to see if there were alternatives, with particular reference to protein supply, which could be used in the UK market. I also wanted to understand more about the environmental challenges that the current ingredients face; to consider what the future holds for pig feed ingredients; and to broaden my knowledge of pig production in other countries.

I believe that soya beans will remain the dominant protein source in pig diets for the foreseeable future, whilst home grown cereals provide the energy and the remainder of the protein. Producers of these ingredients are taking steps to grow their products with due consideration of the environment, and this should be encouraged and supported. However, for some replacements and future opportunities, the same issues of resource availability exist: for example water supply. Where former foodstuffs and co-products of food and industrial processing are used as feed ingredients, both feed and food safety are paramount. Slaughtering stock due to health issues resulting from unsafe feeding practices, or endangering human health with contaminated food, does not contribute to a sustainable future.

Consumers in developed countries have recently been blamed for wasting 30% of the food they purchase, which certainly needs attention. There is also a lot of wastage of resources throughout the food chain. Whilst the UK pig producer can do little about the soya beans that are lost from the back of a lorry while they are being transported from field to port, producers can look at reducing losses within their own businesses to improve overall efficiency.

Sustainability should not mean reduced profitability. In my mind, sustainability is about improving efficiency. One of the key ways to improve efficiency is to reduce wastage through the production system i.e. using less to produce more. If we improve efficiency, we can indirectly have a very positive impact on sustainability.

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