Protein Supply for European Pigs 2010

Protein requirements and supply for a competitive European pig production in 2010

A European Workshop hosted by

fefana

A Sector Group of Cefic

PROCEEDINGS

Brussels, March 18, 2003

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for a competitive
European pig production in 2010

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Proceedings

FEFANA (2003). Protein supply for European pigs 2010.
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Workshop organised by Fefana, March 18, 2003 in Brussels, Belgium

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1.- Introduction

With about 200 million pigs produced per year, and with a forecasted increase by 40 to 50% with the EU enlargement, pig production represents a significant economic factor in the European Union's agricultural sector. Over the past decade, pig production has increased by more than 8% and about 5 – 7% of pork is exported. Globally, however, the EU faces strong competition mainly from North and South America.

The production conditions in the EU are increasingly challenging. Stringent rules on animal welfare, growing environmental constraints and an alerted public in terms of food safety pose practical difficulties and economic burden on all stakeholders in this sector.

On top, the pig sector depends largely on imports for its feed base. The feed cost amounts to some 70% of the total production cost. In particular, the EU is heavily dependent on protein imports. The self-sufficiency for proteins is only in the 30-40% range. The EU feed sector consumes about 30 million tons of soybean meal, which is by far the most important protein feed in the EU, followed by cereals. Turbulences in supply or in US $ exchange rates have an immediate impact on the European feed sector.

Interestingly, only a small fraction of the imported protein is actually utilised. More precisely, it is only a certain percentage of the essential amino acids contained in soya that support pigs' growth and lean meat deposition. Excess protein is excreted as nitrogen, both as gaseous emission and in the manure. Nitrogen in the manure is partly of value as a fertilizer, but excess is released into the environment creating problems especially in areas of intensive animal production.

Thus the EU is on one hand a net nitrogen importer in the form of vegetable protein, while on the other hand, excess nitrogen accumulates in European soils and waters. Could the management of this protein flow be improved? How to make a better use of protein resources, while preserving the efficiency, competitiveness and sustainability of European pig farms?

FEFANA has initiated this workshop to contribute some elements of answer and a forum for debate. It seems indeed that the feed sector, standing at the crossroads of both the crop and the pig sectors, has some assets in hand to support the competitiveness of the European pig production in a sustainable manner.

2.- The March 18 2002 Workshop

2.1 About the organisers

The workshop is organised by Fefana, the European Federation of Animal Feed Additive Manufacturers.

FEFANA was set up in 1963, and joined the Cefic Food & Feed unit in 2001 (European Federation of the Chemicals Industry). Its current membership includes ca. 150 companies, directly affiliated or through National Federations. They produce more than 90% of the additives covered by the EU legislation like vitamins, micro-organisms, amino-acids, flavouring and colouring agents, enzymes, digestive enhancers, emulsifiers, preservatives, silage agents, technological agents, etc.

Fefana is engaged, together with its member companies and national associations, in scientific and public affairs in the feed additive sector. It provides technical information to political decision makers and the scientific community around agriculture.

More specifically this workshop has been prepared by the **Working Party 'Amino Acids'** of Fefana, which deals with issues more specific to feed grade amino acids. This Working Party comprises representatives of the following member companies of Fefana :

- **ADISSEO, France**
- **AJINOMOTO-EUROLYSINE S.A.S. France**
- **ARCHER DANIELS MIDLAND, The Netherlands**
- **BASF AG, Germany**
- **CJ Europe GmbH, Germany.**
- **DEGUSSA AG, Germany**
- **NOVUS Europe, Belgium**

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2.2 Workshop Program

Protein requirements and supply

for a competitive European pig production in 2010

Moderator : Roger Gilbert, International Feed Industry Federation, United Kingdom

10.00 - 10.15 Introduction

Pig production in Europe, quantitative and geographic outlook up to 2010

10.15 – 10.45	**European pig production forecast: European Commission prospects** Rainer Nagel, European Commission, Belgium
10.45 – 11.15	**European pig production forecast: Pig industry prospects** Torben Andersen, Steff-Houlberg, Denmark
11.15 – 11.45	**International challenges for the European pig production** Leo den Hartog, Wageningen University & Nutreco, The Netherlands
11.45 – 12.30	Discussion

12.30 – 13.30 Lunch

Protein supply and demand of a competitive environmental friendly pig production

13.30 – 14.00	**The European protein demand within the global supply** Klaus-Dieter Schumacher, Alfred C. Toepfer International, Germany
14.00 – 14.30	**The role of cereals in the European protein supply** François Gâtel, Arvalis, France
14.30 – 15.00	**Protein input and nitrogen output : the environmental issue** Carlos Piñeiro, PigCHAMP Pro Europa S.A., Proinserga group, Spain
15.00 – 15.30	**The role of amino acids in an environmentally friendly competitive European pig production** Mick Hazzledine, Premier Nutrition, United Kingdom
15.30 – 16.30	Discussion and closing remarks

16.30 End of the workshop

2.3 Speakers and moderator

Roger GILBERT

Secretary General

International Feed Industry Federation

United Kingdom

Rainer NAGEL

Head of pig meat sector

Directorate General Agriculture, European Commission

Belgium

Torben ANDERSEN, M.S. agr.

Technical Director

Durofarm

(until Feb. 28 2003, director at Steff Houlberg Slaughterhouse)

Denmark

Leo DEN HARTOG, Dr

R&D Director

Nutreco

Part time professor at Wageningen University
(Farm development in animal production)

The Netherlands

Klaus-Dieter SCHUMACHER

Head of economics department

Alfred C. Toepfer International

Germany

François GÂTEL, Dr

Head of cereals outlet department

Arvalis, Institut du végétal

France

Carlos PIÑEIRO, Dr

R&D Director

PigCHAMP Pro Europa S.A., Proinserga group.

Spain

Mick HAZZLEDINE

Pig Nutritionist

Premier Nutrition Ltd

United Kingdom

3.- The Commission prospects of the European pig production

Rainer Nagel

Directorate General Agriculture, European Commission, B-1049, Brussels, Belgium

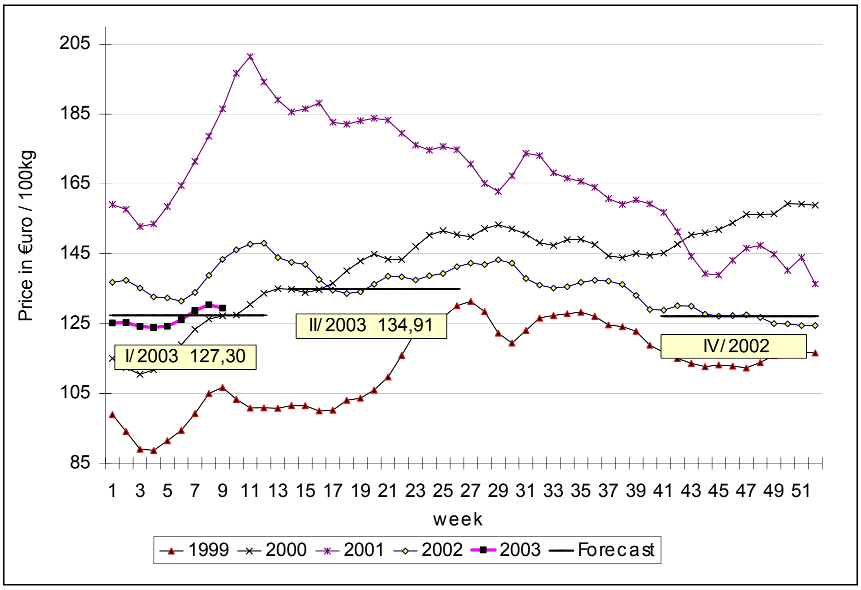
The pig meat market, like the entire EU livestock sector, has been affected by some extraordinary circumstances that are having major consequences for the short term and are expected to influence the medium-term evolution of the sector.

3.1 A hectic past

The new BSE scare in the beef sector, which has created a switch in demand towards other kinds of meat (mainly poultry), has partly benefited the pig meat sector and has contributed to further increases in prices. After the decrease in production recorded in 2000 (-2.4 % compared to 1999), which followed the period of oversupply and very low prices of 1998 and 1999, the pig meat sector benefited from a period of good prices and reasonable margins and, at least in some Member States, there were first signs of investments and increase of the breeding herd. The recent BSE crisis, like in 1996, had a positive impact on pig meat consumption and has therefore further sustained the high level of prices. However, among the measures that were immediately put in place against the BSE, the temporary ban on the use of animal proteins in pig and poultry feed has slightly affected prices of feedstuff and producers' margins.

At the beginning of 2001, the outbreak of FMD in UK and then in Ireland, France and the Netherlands also perturbed the pig meat sector. Animals killed and destroyed for sanitary reasons in the areas touched by the outbreaks affected production in 2001, which was more or less stable at 17.5 mio tons. Around 580 000 pigs were killed and destroyed in the FMD containment and Livestock Welfare Disposal Scheme in the UK.

fig. 1 Development and forecast of the average Community price for pig carcass



Following the FMD outbreak, livestock movement restrictions, together with a large number of export bans imposed by third countries, created major disruptions in slaughterings and sales. The important role of exports for the European pig sector makes it extremely sensible to this kind of epidemics. However, the limited spread of the disease outside the UK prevented major problems and a part of the export ban on EU pig meat was removed after few months. However, the Japanese market remained closed for pig meat from the Netherlands, Ireland and France for more than 12 months. Pig meat exports have recovered after the difficulties linked to FMD and to the triggering of the safeguard clause in Japan. They are now estimated at 1.093 mio t in the year 2001 (just 19% lower than in 2000).

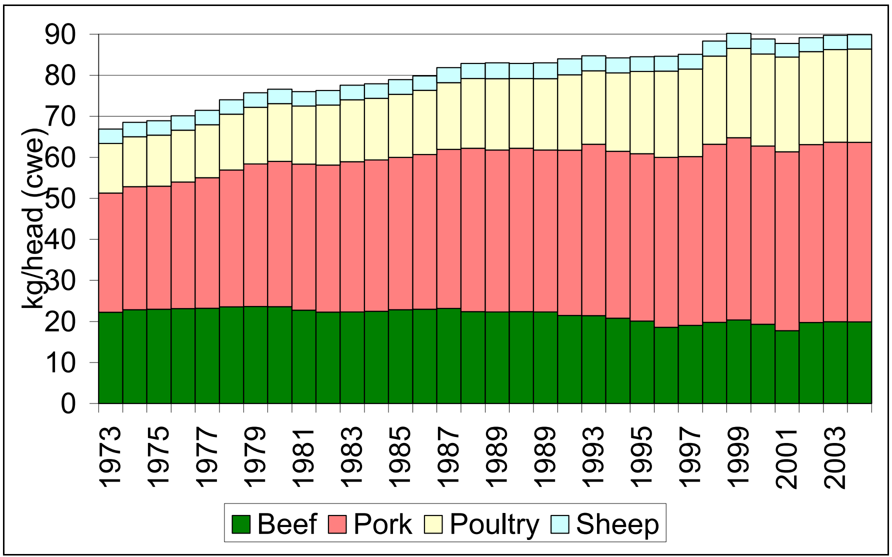
Since December 2001[1], new outbreaks of Classical Swine Fever (CSF) have been recorded in Spain and, to a lesser extent, in Germany, Luxembourg and France. The situation is still not under control mainly in Spain, where a major production area is concerned. However a major impact on total EU pigmeat production is not foreseen.

3.2 Short term prospects

Overall, the last pig census that was carried out across the EU between November and December 2001 showed, with few exceptions[2], an increase of the total pig herd. The number of mated sows was again increasing almost everywhere. The relatively high price level recorded until September 2001 is expected to lead to a major upward adjustment by pork producers and almost all Member States recorded increasing production by the last quarter of 2001.

Pig meat production is therefore expected to increase by around 2 % in 2002, following the positive developments of producer prices and margins over the last year. However, a part of the anticipated increase in production will take place in 2003, where it is foreseen to reach 18.1 mio t (+1% compared to the previous year). Over the long term, there is a certain scope for further expansion, but at a slower rate than in the past. Pig meat production, which is assumed to be driven mostly by demand (internal and external) is, thus, projected to resume its growth and reach around 18.7 mio t by the end of the forecast period.

fig. 2 Meat consumption (EU15, per capita)



The drop in beef per capita consumption, which has been recorded since November 2000 (fig.1), had a positive impact on pig meat consumption (but clearly less than on poultry meat consumption). For the year 2002 pig meat consumption is expected to increase by around 1.5 %. The medium and long-term outlook for pig meat consumption is in general positive since pig meat is likely to continue to be favoured by consumers, although clearly less than poultry. After the increase in 2001 and 2002 in connection with the BSE crisis, the growth rates for per capita consumption are anticipated to slowdown somewhat in coming years, given the expected recovery of beef meat consumption and despite the moderate prices that are expected following the strong increase in production. Pork per capita consumption is projected to increase from 43.7 kg in 2001 to around 45.6 kg by the year 2009.

1 And during summer 2001 for few months in Spain.

2 Total pig herd was lower only in UK (-4.4%), the Netherlands (-10.2%), Belgium (-6.6%) and Luxembourg (-7.7%).

3.3 Mid term prospects

tab.1. Pig meat projections in the EU, 2000 – 2009 ('000 tons carcass weight equivalent)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Production (gross)	17563	17573	17930	18110	18117	18274	18564	18642	18690	18717
Import of live animals	1	1	1	1	1	1	1	1	1	1
Export of live animals	1	1	1	1	1	1	1	1	1	1
Production (net)	17563	17573	17930	18110	18116	18274	18563	18641	18689	18716
Imports	49	53	55	64	69	72	76	80	83	89
Exports	1346	1093	1200	1300	1150	1170	1203	1223	1243	1263
Stock changes	-100	0	0	0	0	0	0	0	0	0
Consumption	16367	16533	16785	16874	17036	17177	17437	17499	17530	17543
p.c. cons. (kg)	43.42	43.74	44.28	44.39	44.69	44.99	45.58	45.66	45.65	45.60

Imports are forecast to increase over the medium term, following the increased market access commitments allowed under the double zero agreements with 10 accession countries. Compared to the relatively low level of 2001 due to export restrictions that followed the outbreak of FMD in Europe, **exports** are likely to be higher in 2002 and 2003, due to the larger domestic availabilities. Exports are projected however to adapt to the supply situation, and therefore contract somewhat in 2004 and then to slightly increase over the medium term in line with higher EU production and growing international trade.

fig. 3 Pig meat production in the enalrged Community : 21.8 million tons

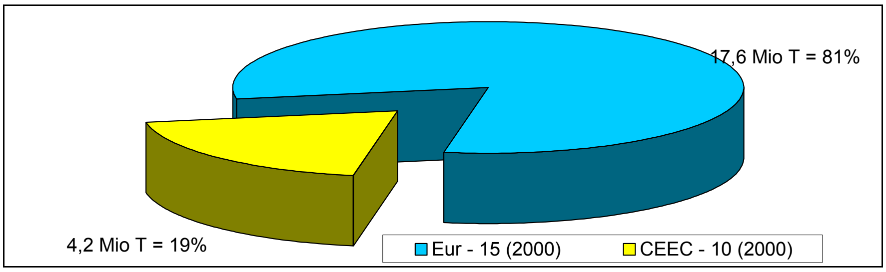
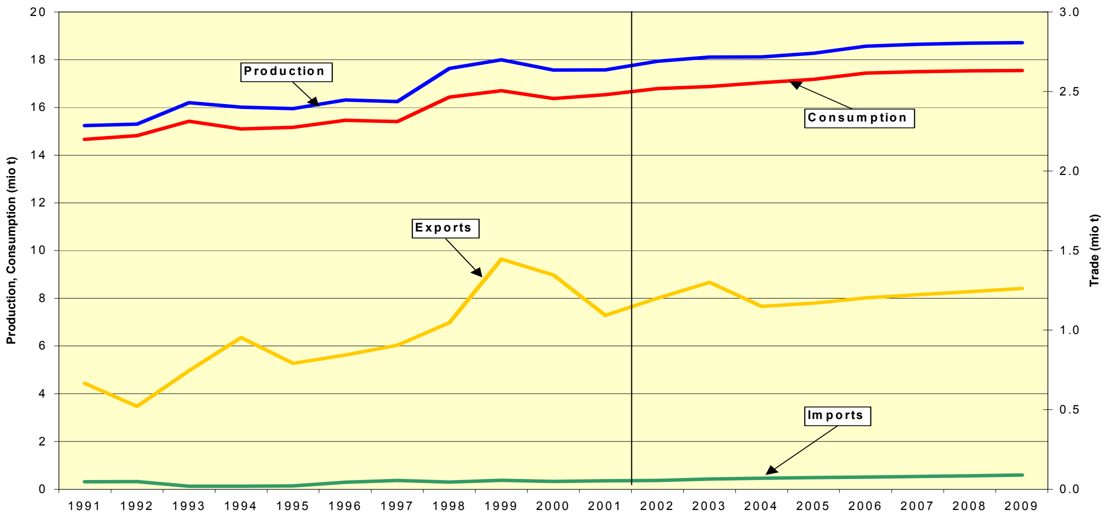


fig. 4 Pig meat projections in the EU, 1991 – 2009 (mio t)



4.- European pig production forecast: Pig industry prospects

Torben Andersen

Durofarm, A/S L. Frandsenvej 4 DK - 5600 Faaborg, Denmark

4.1 Pig production in Europe

The EU pig production is expected to be unchanged or decline a little in 2003. However the trend from recent years, with declining production in UK and Holland continues and the increase in production is in Spain, Denmark and to a limited extent in Germany. The increase in Finland and Sweden and the reduction in Belgium and Luxembourg are insignificant to the total production in EU. The major changes in pig production occur in Russia and Canada. The growth in Brazil seems to become less than expected, the reason probably being low world market prices and difficulties in exporting bulk meat.

In the expanded EU it is worthwhile to look at the development in the production in the 10 applicant countries. Poland is the only significant pig producer that has maintained its production in the last decade of last century. In most countries the production is reduced by a third and totally the production has been reduced from 60 to 46 million pigs per year. At the same time the production in EU increased from 185 to 200 million pigs per year, reducing the East European proportion of the EU-15 production from 33 to 23 percent.

tab.2. Slaughtering in Eastern Europe and EU15, 000 heads

Europe slaughterings, source GIRA

	1990	2001
EU-15	**184 770**	**200 200**
% total enlarged Europe	75%	81%
East European counties	**60 013**	**45 825**
% total enlarged Europe	25%	19%
Poland	19 464	22 900
Hungary	10 697	5 700
Romania	9 576	6 200
Tchech republic	9 225	4 600
Slovakia		1 630
Bulgary	5 140	2 300
Slovenia	700	780
Estonia	1 080	490
Latvia	1 401	405
Lithuania	2 730	820
EU-25	**244 783**	**246 025**

This development is expected to continue when the East European producers meet the competition from the rest of Europe. It will take several years until the industry can meet the competition.

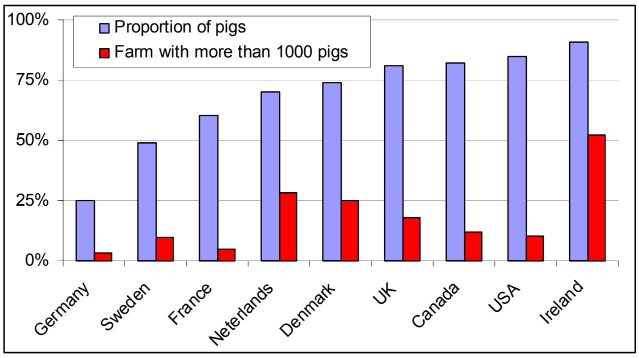
In the next 10 years the East European pig production will almost be unchanged, but with an increasing demand/consumption there will be a need for import from the old EU countries. The "old" EU countries is expected to have an increase in consumption and an even higher increase of the production, so the result is that they can fill the market in the new countries alongside with an almost unchanged export to third countries outside EU 25.

tab.3. Export potential in EU 25

In million tons	2001	2007	2012
Eastern Europe			
Production	4.34	3.98	4.22
Consumption	4.17	5.16	5.5
Export potential	0.17	-1.18	-1.28
EU 15			
Production	18.05	19.96	20.59
Consumption	16.96	17.4	18.02
Export potential	1.09	2.56	2.57
EU 25			
Export potential	1.26	1.38	1.29

The structure of the pig production is quite different in the countries that we normally compare. In Canada around 12 % of the farms are over 1000 pigs. These 12 % of the farms however produces over 80 % of the pigs. On the other hand Germany has only 3 % of farms over 1000 pigs being responsible for 26 % of the production. Consequently a large proportion of the production comes from relatively small farms under 1000 pigs. The most extreme is Ireland where over half of the farms have over 1000 pigs and they are producing over 90 % of the production. The structural change is very rapid and in many countries enhanced by integrators. For instance in the USA, 20 integrators produce more than 500.000 pigs per year and they account for around 35 % of the total production.

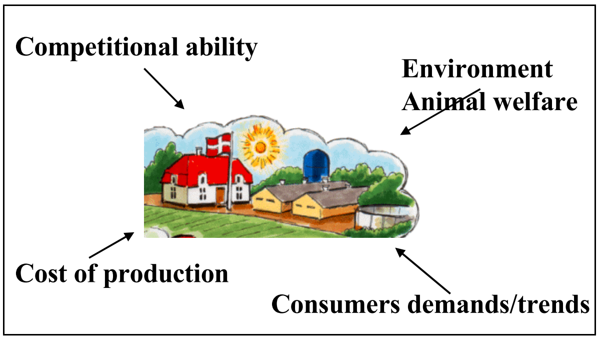
fig. 5 Herd structure in various countries



4.2 Challenging production costs

Many factors are influencing the industry. Cost of production is the major factor, but also different consumer demands and trends (often supported by press and politicians) are challenging the ability to compete with countries with a more liberal attitude to environment, animal welfare and use of drugs and medicine.

fig. 6 Factors impacting the swine industry



A comparison of costs between selected countries clearly shows that the cost of production is quite different. The lowest costs are in Canada and the highest in UK. The difference is around 30 %. Different prices of pig meat partly compensates for the difference, but in a longer perspective the prices will be more uniform, so if the cost picture does not change the production will shift to countries with the lowest production costs.

The different costs basically relates to different production results. Sow fertility is a key factor. The number of piglets per sow per year is related to the genetic potential in pigs. Also here there is a major difference between countries. The best results are achieved in countries with a well-organized breeding programme. This shows that high costs can be overcome to some extent by improving technology. As seen from table 4 feed costs are very different from America to Europe, and as with the fertility, good technical results can compensate for high feed prices.

tab.4. Cost factors in various countries

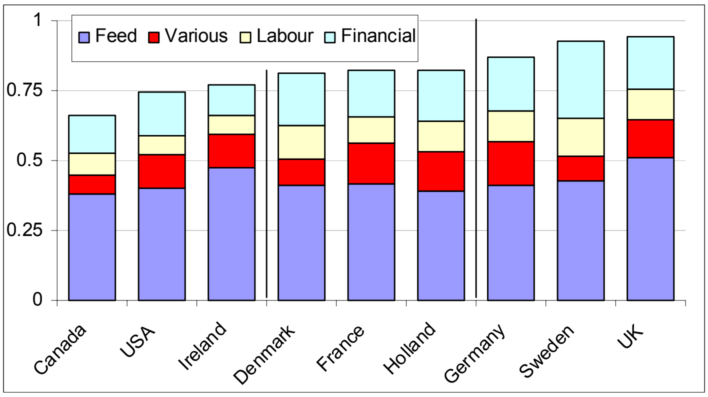
	Canada	Denmark	France	Germany	Ireland	Netherlands	Sweden	UK	USA
Pig/sow/year	18.2	21.9	19.5	19.0	21.5	21.9	20.4	20.4	18.0
Live born / litter	9.7	11.8	10.8	10.8	10.9	11.3	11.3	11.0	9.7
Feed cost, Euro/kg carcass	0.38	0.41	0.45	0.41	0.47	0.39	0.43	0.51	0.40
Feed conversion rate	3.28	2.70	2.81	2.94	2.68	2.62	2.79	2.62	
Interest and depreciation, Euro/kg carcass	0.128	0.174	0.151	0.177	0.096	0.168	0.258	0.169	0.151
Labour cost, Euro/kg carcass	0.08	0.12	0.09	0.11	0.07	0.11	0.14	0.13	0.06
Production cost, Euro/kg carcass	0.63	0.82	0.82	0.86	0.77	0.82	0.80	0.91	0.74

Interest and depreciation mostly shows differences in building costs. It is obvious that costs are higher in countries with extended legislation about animal welfare and stricter regulations regarding area per pig and special production systems.

Labour costs are low in USA – around half of UK and Scandinavia. Again, if the labour costs are high, normally the prices of pig meat are a little higher. If they get to high of course the retailers will import pig meat to the country, so it is a delicate balance of “national preference” and price of domestic meat versus imported meat.

Summarizing the cost picture the countries can be split in low, medium and high cost areas. The difference is around 25% with Germany, Sweden and UK as the high cost. These countries are importers of pig meat, so normally the payment to the producer is higher because of the above-mentioned “national preference”. To meet the challenge from low cost countries it is necessary to maintain a high technical level. The figure shows the goals for average results set by the Danish industry.

fig. 7 Cost structure in various countries (year 2000, in Euro/kg carcass)



tab.5. Goal for improvement in pig productivity in Denmark

	2000	Goal
Weaner, 7-30 kg		
Daily gain, g/d	407	550
Feed conversion rate, FEs/kg	-	1.6
Mortality, %	3.6	2.0
Finisher, 30-100 kg		
Daily gain, g/d	798	1000
Feed conversion rate, FEs/kg	2.89	2.50
Lean meat, %	60.0	62.5
Mortality, %	3.6	1.0

4.3 Accounting for consumer trends

In our part of the world with abundant food resources many consumers do not accept the philosophy that crops are chemically protected. They see it as an almost “criminal” desire to make profit. Instead they want clean products without any risk of residues. Furthermore they also want a clean conscience towards the animals, so animal welfare has been on the agenda for quite some time. The political consumer that regardless of price buys the “right” products was 10 years ago expected to become the majority. This has not happened - perhaps because the worst systems have been removed.

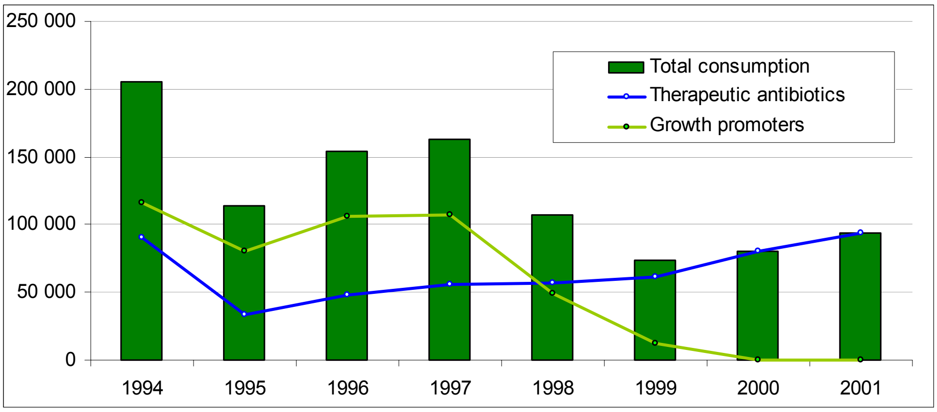
- **The ban of antibiotic growth promoters**

fig. 8 Danish past position towards antibiotic growth promoters

1995	**National ban on Avoparcin**
	Voluntary agreement between NCPP and the feedstuff industry to minimize the use of AGP’s
1998	**National ban on Virginiamycin (Jan)**
	Voluntary agreement to ban AGP’s for finishers (Mar)
	National tax on AGP’s (Sep)
	Action plan to phase out AGP’s for piglets as of 1-1-2000
1999	**EU ban: Tylosin, Bacitracin, Spiramycin and Virginiamycin**
	EU ban: olaquindox and carbadox
2000	**Voluntary agreement to ban AGP’s for piglets**

The political consumer, however, has had great influence on the political agenda and in some countries led to legislation. For instance in Sweden and Denmark antibiotic growth promoters have been banned, not because of a residue problem but only because the idea that the meat has been "contaminated" was not accepted – not even if it was well documented that the meat was clean at time of slaughter.

fig. 9 Consumption of antibiotics in Denmark, active matter, kg/year



For the Danish industry it was a major challenge to solve the problems that arose when antibiotic growth promoters were banned. The amount for therapeutic use has increased but the total use of antibiotics is now half of what it was 8 – 10 years ago. The feed industry has been a key player in solving diarrhoea and other weaning problems. More amino acids and feed with higher biological value are tools and a lot of different natural products are tested to achieve the goal.

- **Animal welfare**

Animal welfare with loose sows, extra area requirements, audits on farms etc... has been an increasing cost factor the last 10 years. It now seems that the legislation is about to be almost the same in all EU. Some countries like UK, Sweden and Denmark have made a great part of the welfare investments already while other countries like for instance Spain, France, Italy and partly Germany has a long way to go. The new EU countries have not begun yet so it can be expected that some huge investments in animal welfare will happen in the years to come.

- **Meat quality**

Lean, clean, no stress, tasty and tender are words that consumers like to hear about the meat. Meat quality has been discussed for years and the only thing that is widely accepted is that it must be lean and tender. The other quality parameters normally disappears in the discussion.

- **Ammonia emissions**

Many efforts are being used to reduce ammonia emissions. In many areas farmers must demonstrate that they take measures to reduce ammonia emissions to obtain permission to establish or increase their pig production. Part of the reduction is achieved by improved housing design and part by feeding the right feed. Reduction via change of housing design takes time and is expensive, so to quickly reduce the ammonia emissions it is necessary to improve and adapt feed to also serve this purpose.

To conclude I think the pig meat consumption both in Europe and the rest of the world will increase with increasing wealth and population. The increasing consumption in Eastern Europe will exceed the increase in production in Eastern Europe. So even with relatively unchanged consumption in the present EU, the demand within EU 25 will leave the net export from EU at its present stage.

The high European costs hopefully are compensated by steadily improving efficiency.

The consumer demands will include the concepts: Clean, environment friendly and animal welfare. I do not expect a hysterical trend in this direction, but the direction is clear.

5.- International challenges for the European pig production

Leo den Hartog

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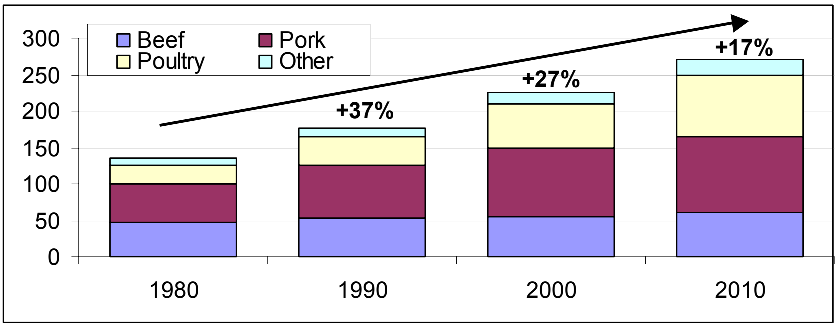
Department of animal sciences, Wageningen University, Wageningen, The Netherlands

The world population has increased during the last decades and will increase further during this century. Due to this and to the increased meat consumption per person global consumption of meat will rise. The last 40 years the global pork production increased with a factor 3.5 from 24.7 million ton in 1961 to 86.6 million ton in 2002. Figure 10 shows the world market demand for meat including pork.

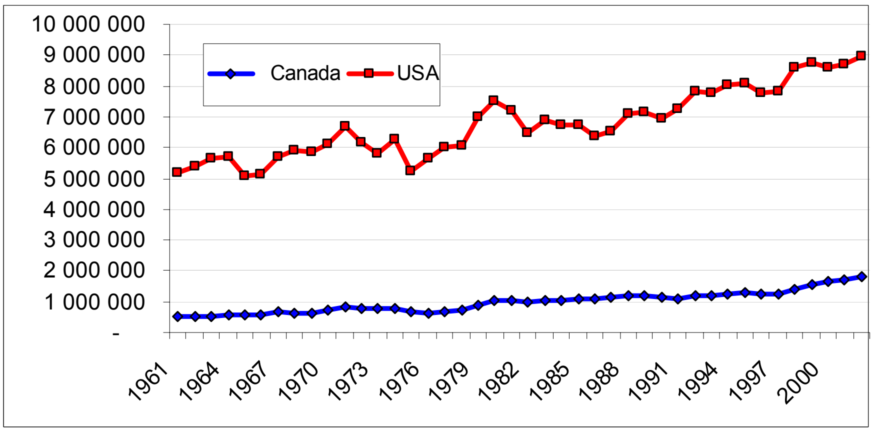
fig. 10 The world market demand for meat (Source: Rabo N.D. Mulder, Projection Fapri 2001, FAO)



5.1 Production area

The main production areas for pork are East Asia, North America and Europe. In eastern Asia there is a shortage of land and feedstuffs for animal production. Japan is a main importer of pork. China however contains nearly 50 % of the world pig population. When the developments of increase in pork production in China will continue, more than 50 % of the pork production in the future will occur in this country. In the USA and Canada pork production has increased during the last decade. (see figure 11).

fig. 11 Development of pig meat production in the USA and Canada across 40 years (tons/year, Source FAO)



The USA changed from an importing country in a pork exporting country. Export of pork is 4 times more profitable than the export of grains. In Southern America, especially Brazil, the production circumstances are good: feedstuffs are available, labour is cheap and there is enough land available for manure. Animal production develops rapidly in this part of the world. Also in Europe several changes occur. The EU, for example, will expand. This means an increase in EU member state population of about 110 million people. The surface of the EU will increase with about 33 % but the area of fertile agricultural land will be enlarged with 55 percent. The Eastern European countries have relative cheap labour and land prices are also relative low.

Tables 6 and 7 show the amount of imported and exported pork in 1990, 2000 and 2002. It can be concluded from these tables that the biggest increase in pork export happens in N. America and Brazil.

tab.6. Import of pork per country (x 1000 ton carcass weight, Source GIRA 2002)

	1990	2000	2002
Japan	497	847	962
US	483	745	842
Russia	489	486	817
CEEC	201	227	303
Mexico	-	185	291
S. Korea	-	182	173
China	-	149	141

tab.7. Export of pork per country (x 1000 ton carcass weight, Source GIRA 2002)

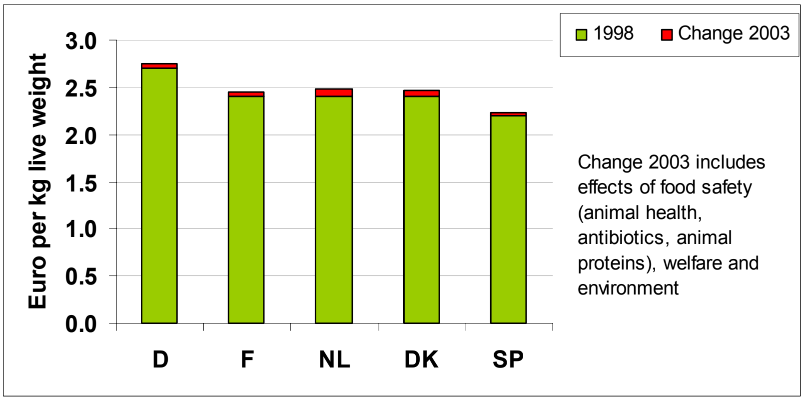
	1990	2000	2002
EU	807	1321	1163
Canada	380	886	1079
US	109	600	735
Brazil	-	155	522
CEEC	323	266	323
China	443	59	188

The West European market is characterized by:

- Change from production oriented to market oriented
- Critical consumers with wishes concerning way of production
- Large own market consisting of consumers with a relative high income
- High production costs compared to other areas.

But even in western Europe cost prices of pork production differ per country (see figure 12).

fig. 12 Long term cost prices for pigs (per kg live weight) in the EU (incl. calculated interest & labour costs, specialised closed farms, source AEI, NL)



The cost price per kg live weight is lowest in Spain. However the within country variation in cost price is bigger than the between country variation which means that the 25 % best farmers in Denmark, France and the Netherlands for example have a lower cost price than the average in Spain. The cost price in Western Europe as an average is higher than in e.g. the US, Canada and Brazil.

This means that in Western Europe we should be aware of the wishes of the consumers concerning products and way of production. Because there is a variety in consumers and therefore in products different supply chains should be built. The consumer expects attractive, nutritious and safe food from environmentally responsible and sustainable sources for a fair price. The keys for the successful future of pork production are:

- Food safety
- Quality assurance and transparency
- Sustainability in production

- Variety of products which are easy to prepare.

5.2 Supply chain

In order to fulfil the market wishes, several companies developed supply chains in which breeding, feeding, husbandry and processing are related. Optimization of the supply chain and specialization of the processing plants are used for further improvement of the product quality for bacon, industry, retail and food service.

In Europe pork is mainly consumed in a processed form especially in the UK, Germany and Italy. The share of fresh meat prepacked purchases also grows steadily. The percentage of fresh prepacked meat increased in the Netherlands from 42 in 1190 to 76 in 2001. The supermarket share in retail meat purchases keeps growing from 61 % in 1990 in the Netherlands to 78 % in 2001. The importance of prepacking, processing, fresh products and supply chain management will increase in the future. In order to differentiate in the EU from non EU pork producers we have to act close to the consumer and focus on the aforementioned aspects.

The five basic items which may effect the supply chain are:

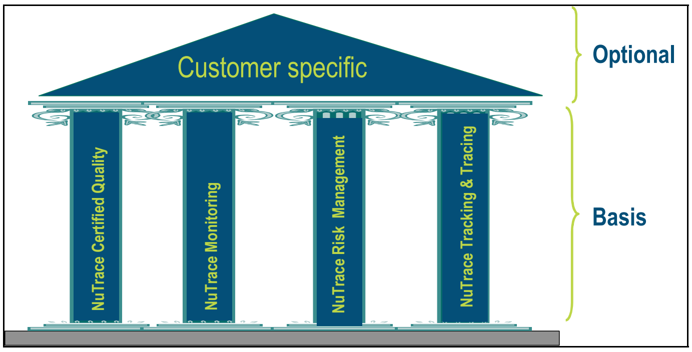
- food safety
- quality
- production circumstances
- cost price
- information.

- **Food safety**

Food safety is priority in all parts of the production chain nowadays. The first essential step in a food safety program is a good risk analysis (actual and perceived risk) which exist of risk assessment, risk management and risk communication. In order to guarantee the consumer that the products are safe four key characteristics in the Nutreco quality program NuTrace® (see figure 13) are defined:

- development of food quality assurance programs (certified quality)
- development of tracking and tracing systems
- effective risk management and preparedness
- monitoring the whole food value chain

fig. 13 NuTrace®, based on four pillars



- **Quality systems**

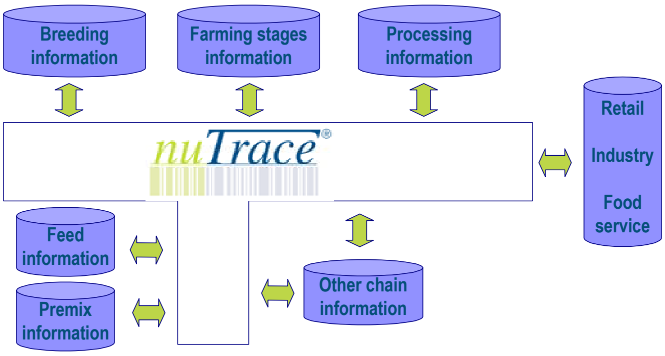
The food quality assurance program fits with the specifications of the Global Food Safety Initiative. This initiative was launched by a group of international retailers and is a market oriented approach to assure food safety. However in several countries national requirements are involved as well.

For this purpose not only a good contact with the customers is needed but also an intensive contact with NGO's, governmental organizations and politicians is necessary.

- **Tracking and tracing**

Tracking and tracing through the whole chain and also to the suppliers is necessary in order to state the guarantees. Therefore NuTrace® tracking and tracing is developed which contains information concerning the product and the production process on for example: breeding, farming, feeding, delivering, processing and packing (figure 14). This means that the NuTrace® tracking and tracing system contains all the integrated information from feed raw materials through to processed products all in one database. This makes it possible to trace back within a few minutes from meat to for example the used feed ingredients in order to produce that meat. NuTrace® starts with traceability, evolves into transparency and leads to trust.

fig. 14 NuTrace®, Tracking & Tracing.



An example of a new technology that has been installed to track and trace meat products during processing is the DOT code system. The DOT code is put on the hams, backs, bellies and shoulders of the carcass by an advanced robot. Also the boxes with the smaller meat cuts can contain this code. In this way the customer has not only access to information of the product but also to the production process like breeding, feeding, health inspection and classification. This is the way to a complete transparent production.

- **Risk management**

In order to build confidence with customers and to react in an adequate and accurate way effective risk management policies and procedures are necessary.

- **Internal and external monitoring**

Monitoring at all parts of the chain is essential. Suppliers are audited and raw materials checked rigorously at company laboratories. The traffic light procedure for suppliers is used. Only suppliers with a green light are allowed to deliver their products to Nutreco companies. Suppliers with a red light are not allowed to deliver and those with an orange light have to be double checked. All the results of the monitoring procedure are communicated with the supplier. Detection methods for rapid and accurate indication of the presence of contaminants or undesired micro-organisms are developed. An example is the Calux analysis for rapid dioxin analysis.

- **In conclusion**

Total Quality Management through the whole production chain is the only way to fulfil the demands of the consumers and to offer them safe, nutritious and attractive meat products for a fair price.

Food safety and a customer oriented supply chain production are the items now and for the future.

6.- The European protein demand within the global supply

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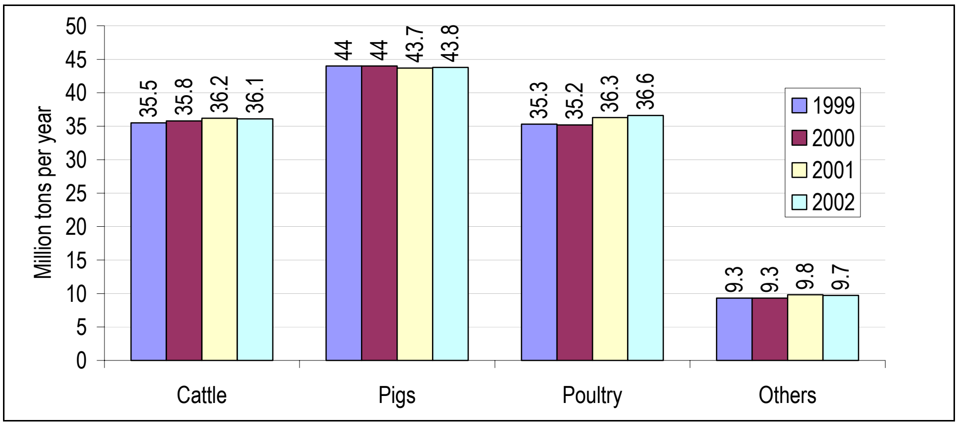
6.1 EU compound feed production

Total compound feed production in the EU could rise slightly to around 125.8 million tons in 2003, some 200,000 t more than in 2002 (fig. 15). Pig compound feed production will reach an estimated 43.9 million tons this year, the same amount produced last year. A further increase in poultry compound feed appears probable, however, not to the same extend as in the year before.

fig. 15 EU compound feed production



For cattle feed the reduction in stocks affected on the total volume. Production declined last year by 300,000 tons. Further reduction by about 1% is expected as a result of the decline in number of dairy cows.

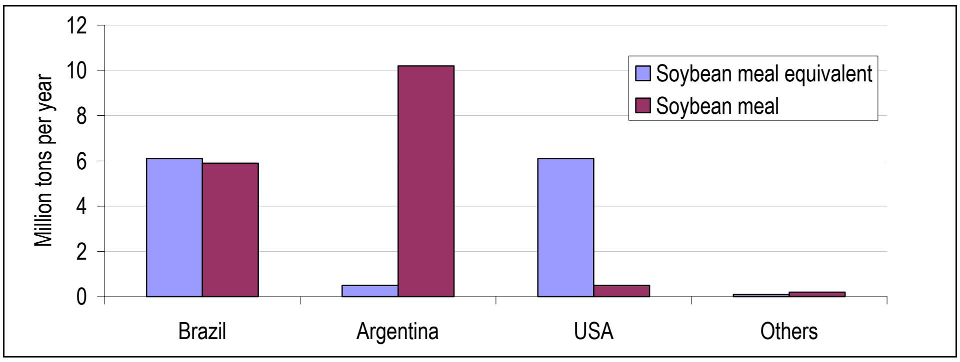
The share of grain in compound feed in the EU is expected to rise in this marketing year to 53% from 51% last year (2000/01 – 49%). The amount of grain being used in compound feed and for direct feeding on farms is expected to rise by more than 2% to a good 120 million tons.

- **Use of ingredients**

The EU's livestock sector is highly dependant on imports of feed raw materials. This is first of all the case for protein feed. In this sector the EU has only a degree of self-sufficiency of about 35 %, whereas imports account for 65 %. Total demand for protein feed in the EU reached about 43 million tons in 2002. Out of this total over 28 million tons had to be imported from countries outside of the EU.

With a consumption of around 30 million tons, soybean meal is by far the most important single protein feed in the EU (fig. 16).

fig. 16 EU soybean meal use by origin in 2002/2003 (total approx 30 million tons)

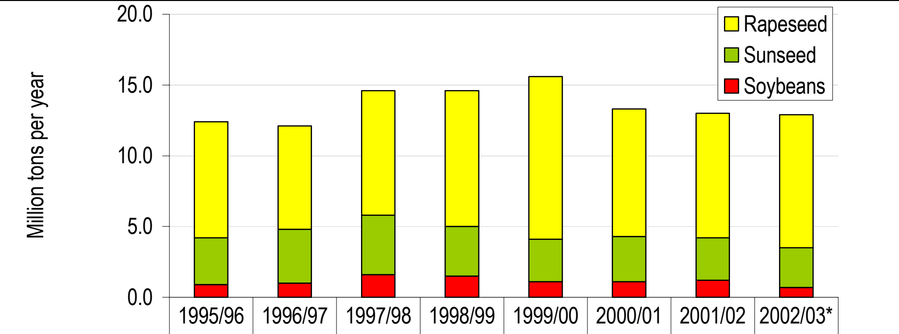


Imports contribute nearly 50 % to the EU's domestic consumption of soybean meal, whereas the second half results from crushing of imported soybeans. The EU contributes about 23 % to the worldwide consumption of soybean meal. The only country with a slightly higher domestic use is the USA.

The major producing countries of soybeans are also the major suppliers of soybeans and soybean meal for the EU: The USA, Brazil and Argentina account for over 95 % of all EU imports of these two commodities.

The major domestic sources for protein feed in the EU are rapeseed meal and sunflower seed meal. The annual EU production figures for these crops are shown in Fig. 17 and vary between 15.6 million tons in 1999/00 and 12.8 million tons in 2002/03.

fig. 17 EU production of oilseeds, million tons per year

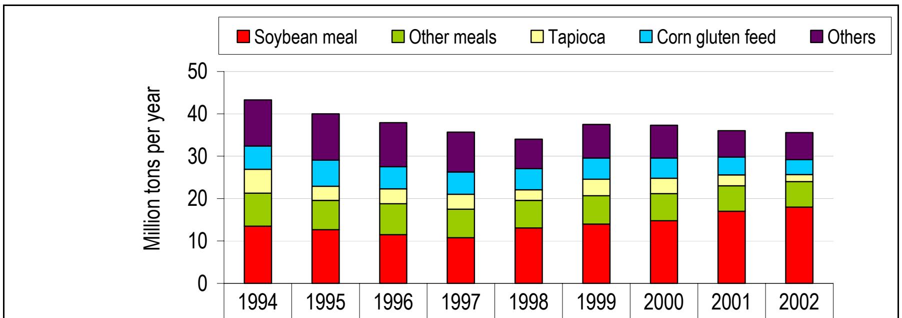


	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03*
Rapeseed	8.2	7.3	8.8	9.6	11.5	9.0	8.8	9.4
Sunseed	3.3	3.8	4.2	3.5	3.0	3.2	3.0	2.8
Soybeans	0.9	1.0	1.6	1.5	1.1	1.1	1.2	0.7

Annual EU consumption varies with the size of the EU's own rapeseed and sunflower seed crops. In 2002/03 consumption of these two feeds is expected at 8.6 million tons, thereof 5 million tons of rapeseed meal and 3.6 million tons of sunflowerseed meal. Imports of rapeseed meal are seen at only 0.4 million tons, whereas imports of sunflowerseed meal are seen to reach 1.7 million tons (nearly 50 % of domestic consumption).

All other major protein feeds used for livestock production in the EU originate in non-EU countries. The most important items are palm and copra products with an import volume of close to 3 million tons with Indonesia, Malaysia and the Philippines being the suppliers. Moreover, the EU imports about 4.5 million tons of corngluten feed annually, nearly 100 % from the USA. The EU import figures for the major ingredients are shown in Fig.18.

fig. 18 EU imports of feedstuffs, million tons per year



	1994	1995	1996	1997	1998	1999	2000	2001	2002
Others	10.9	10.9	10.4	9.4	6.9	7.9	7.7	6.2	6.4
Corn gluten feed	5.5	6.2	5.2	5.3	5.0	5.0	4.8	4.2	3.5
Tapioca	5.6	3.3	3.5	3.5	2.5	3.9	3.6	2.6	1.7
Other meals	7.8	6.9	7.3	6.7	6.5	6.7	6.4	6.0	6.0
Soybean meal	13.5	12.7	11.5	10.8	13.1	14.0	14.8	17.0	18.0

The EU's dependency on imports of protein feed will not disappear in the years to come. The EU lacks the agronomic conditions to significantly increase the production of oilseeds and oilseed meals. Also, the recently tabled reform proposal will limit the growth potential for oilseeds in the EU.

6.2 Mid Term Review and Protein Supply

Particular important for the farmers and sectors related to agriculture is the progress of negotiations within the framework of the Midterm Review of Agenda 2000. As it is generally known, the Commission presented its proposals for the further development of EU agricultural policies already in July last year. Due to resistance encountered on the part of some member states and the agreement made with regard to the EU budget, the Commission had to rework its proposals.

It appears, that the Commission is not planning any proposals that will result in further reform of the grain market. According to the Commission proposals they will likely recommend a final 5% reduction in the intervention price, coupled with an increase of the direct payment from € 63 to € 66 per ton.

Subsidies for oilseeds will remain at the level of the cereals and also be increased accordingly. However, set aside areas that now can be used for non-food crops are to be transformed into a 10% permanent set aside area. This cuts the possibility to grow non-food crops on them and reduces the area for planting industrial oil seeds.

The subsidies for pulses will be increased by 55.57 €/ha in addition to the 66 €/ton. However, the Commission put a ceiling of maximum 1.4 million ha eligible for these payments.

Consequences are that the proposals of the EU Commission within the Midterm Review would have no impact on the self-sufficiency rate for protein crops within the union. Production of pulses may theoretically increase by 30%, representing about 1 million tons additional crops, being just 4% of the total EU production.

The effects of the Midterm Review on the oilseed area are difficult to predict. The EU expects an extension of the planted area, although the available area is decreasing. The reason is the expected increases in price. It can be assumed that prices for oilseeds will develop more positively compared with the prices for cereals. This may lead to a shift in the planted area in favor of oilseeds (tab.8).

tab.8. Impact of midterm review on plantings of arable crops (Source EU Commission 2003)

	EU-15				CEEC-10			
	2002	2004	2007	2009	2002	2004	2007	2009
Cereal area	37.4	36.9	36.7	36.5	23.9	23.4	23.3	23.3
Oilseed area	14.0	4.5	4.6	4.7	3.1	3.5	3.5	3.6
Pulses area	1.2	1.2	1.2	1.2		?		
Set aside	5.8	6.2	6.3	6.4		?		

6.3 EU-Enlargement

The enlargement of the EU to include the countries in Central and Eastern Europe as well as Malta and Cyprus in 2004 presents a big challenge. The internal market will grow from around 380 million citizens to more than 450 million. The Commission and the candidate countries had to work out many details. E.g. in the agricultural sector it was necessary to structure the intervention and introduce an integrated monitoring and administrative system for settling direct payments.

In the year of entry, the new member states will get only 20% of the subsidies compared with the Western European countries if no additional national subsidies of up to 25% will be granted. The potential total thus becomes 45%. Distribution of payments will be accordingly. That means the same subsidies for oilseeds and cereals and higher payment for pulses. It is not expected that the area for sunflower seed will be extended considerably. Currently in the new member states it is 1.35 million ha, equivalent to 2.5 million tons.

But there is potential for rapeseed and soybeans. Rapeseed is currently 1.24 million ha, equivalent to 2.6 million tons and soya is 89,000 ha, equivalent to 130,000 tons. The extension of planted area is difficult to judge. The EU Commission expects an increase of 400,000 ha, equivalent to 700,000 tons of oilseeds. Anyhow, the planted area and also the yields will grow slowly.

Also livestock production will increase only slowly in the first years after entry into the EU. Structural changes though will lead to an increased demand for high quality protein feeds. Poland currently imports 1.5 million tons and Hungary 800,000 tons of soybean meal.

6.4 Meat and Bone Meal

The ban of meat and bone meal for ruminants and other animals will most likely be extended in this year. Chances are that it will be allowed for non-ruminants in 2004 under strict control mechanisms (no cannibalism). That would mean strict separation of production, processing and transport and render meat and bone meal to a niche product, if the European compound feed industry would re-accept this product at all.

6.5 Bio fuel

The EU parliament has declined to set minimum blending levels of bio fuel to normal fuel. Member states can strike voluntary agreements without adhering to a minimum level. Compulsory minimum blending levels could have contributed to increase rapeseed production from 2005 onwards. The voluntary agreements will achieve only small increases. The production capacities for bio diesel have been increased significantly again last year. For 2003 they are estimated being 1 million tons, that is equivalent to 2.5 million tons of rapeseed. Increased demand for bio diesel can be expected, also in Eastern Europe, where bio diesel plants are under construction or in planning.

6.6 Summary

The developments highlighted above have only limited impact on the mid term supply with protein meals in the EU. National supply may increase marginally but a strong dependency on imports will further remain. The EU lacks the agronomic conditions to significantly increase the production of oilseeds and oilseed meals. Also, the recently tabled reform proposal will limit the growth potential for oilseeds in the EU.

7.- The role of cereals in the European protein supply

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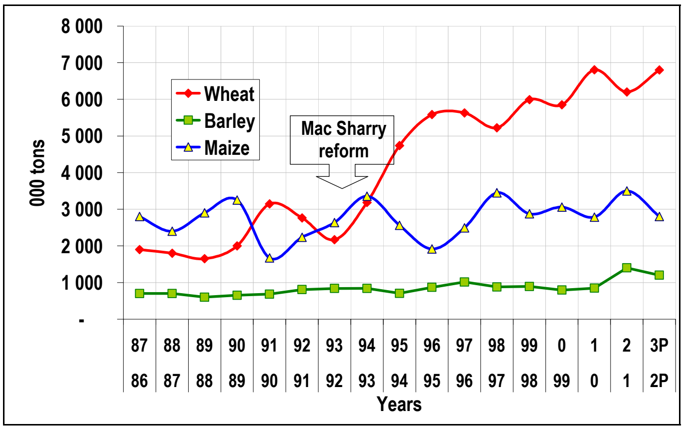
Protein supply is generally considered in terms of protein rich feedstuffs i.e. containing a minimum amount of crude protein (e.g. above 25%). However, as developed here-after, numerous feedstuffs used for their energy content also contribute to a large extent to livestock protein supply. In this sense, due to their important inclusion in pig feeds, and despite a limited crude protein content (8 to 12 %) cereals play a significant role in protein supply for pig production. After reviewing the current cereal contribution to pig feed protein requirement in France and in Europe, we will study briefly which factors impacts cereal usage and thus cereal contribution to protein supply; finally, we will assess the consequence of cereal usage in pig diet on nitrogen output.

7.1 Current cereal contribution to pig feed protein requirement

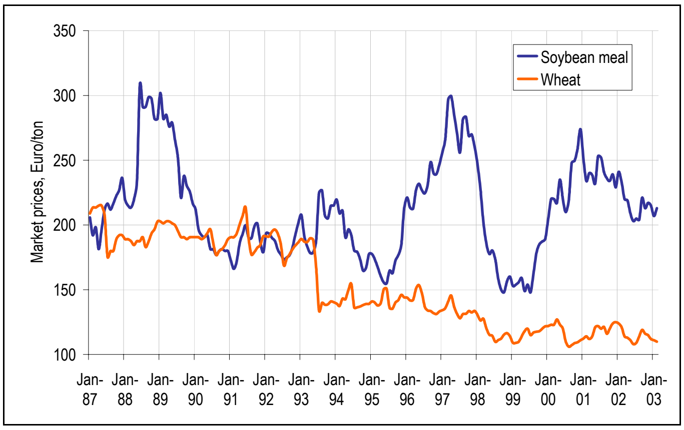
In the past 10 years, following the Mac Sharry reform usage of cereals in feedstuffs greatly increased in the European Union, as illustrated in fig.19 for France. This increase was especially noticeable for wheat, whereas barley and maize usage remained on a stable tendency despite year to year changes.

fig. 19 Past evolution in cereals usage by French feed compounders (all species, Onic monthly report, Feb 2003)



This increase in wheat inclusion resulted from the significant decrease of wheat prices induced by the reform in the early nineties (fig.20).

fig. 20 Wheat and soybean meal price evolution across the past 15 years



With the aim to asses the present contribution of cereal to European pig feed, four sources of information were considered, each of them giving access to a rough estimate of an average pig feed formula (tab.9).

- A reference growing-finishing formula implemented by the CEREOPA (Centre d'Etudes et de Recherche sur l'Economie et l'Organisation des Productions Animales) to follow up the French feed market.
- A reference growing-finishing formula implemented by UNIGRAINS (an investment company specialised into food and feed sectors) to follow up the Britain feed market.
- A reference growing-finishing formula proposed by AJINOMOTO EUROLYSINE deducted from various exchanges with feed formulators across Europe, and finally
- A reference feed formula derived from EU statistics on feedstuffs usage in animal compounded feed. The appraisal can be made that pig feed composition is intermediate between ruminant and poultry and thus can be approached through average animal feed composition.

tab.9. Estimated cereals protein contribution in today European feeds

	Estimated inclusion rate				Feedstuffs protein level	Estimated protein supply			
	% pig feed (CEREOPA)	% pig feed (UNIGRAINS)	% pig feed (AJINOMOTO)	% feed (all species)	(INRA 2002, % feedstuffs)	% CP (CEREOPA)	% CP (UNIGRAINS)	% CP (AJINOMOTO)	% feed (all species)
Wheat	23.8%	48.9%	25.0%	23.1%	10.5	15%	34%	16%	14%
Maize	10.9%	7.1%	10.0%	16.9%	8.1	5%	4%	5%	8%
Barley	20.2%	11.4%	25.0%	18.4%	10.1	13%	8%	15%	11%
Other cereals	0.4%	0.0%	5.0%	7.1%	9.5	0%	0%	3%	4%
Wheat by products	11.6%	9.5%	5.0%	6.5%	15	11%	9%	4%	6%
Peas	11.9%	6.2%	3.0%	3.2%	20.7	15%	8%	4%	4%
Soybean meal	12.4%	10.4%	14.0%	15.9%	45.3	34%	31%	38%	42%
Rapeseed meal	2.8%	2.8%	5.0%	3.6%	33.7	6%	6%	10%	7%
Sunflower meal	0.3%	0.0%	3.0%	2.7%	30.6	1%	0%	5%	5%
Total	94.3%	96.3%	95.0%	97.4%					
CP, % feed						16	15	17	17
Cereals and cereals by products	**67%**	**77%**	**70%**	**72%**		**44%**	**54%**	**43%**	**42%**

The proportion of any particular raw ingredient varies according to the different references: for instance wheat proportion varies from 23 to 49% according to the different sources; however the proportion of all cereals, or, of all cereals plus cereal by products is more consistent and reaches 55 to 67 and 67 to 77 % of the diet respectively. In these conditions, and taking into account the protein content of feedstuffs, the contribution of cereal to the protein supply of pig is 34 to 46% (and that of cereal plus cereal by products is 42 and 54 %, tab.10).

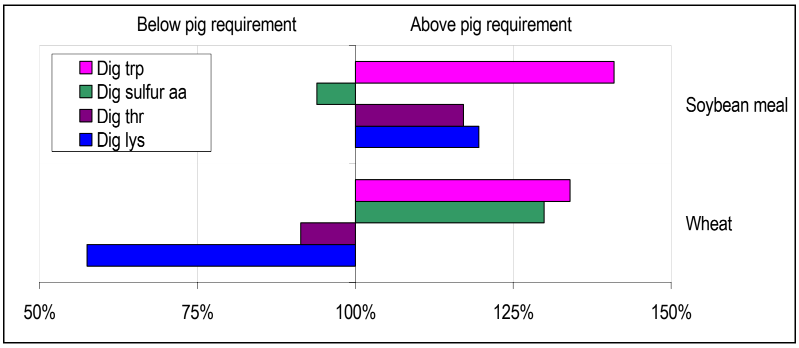
When multiplying the estimated amount of cereals and cereal by products by their protein contents (assuming a feed amount for pig feed of about 70 million tons of feed) it appears that cereals and cereal by products bring about 5 million tons of protein. This means that cereals contribution is thus equivalent to the soybean meal one, with the difference that cereals are mostly grown in Europe while soybean meal is imported.

tab.10. Protein tonnage brought by each category of feedstuff to formulate 70 million tons of pig feed, 000 tons/year

	(CEREOPA)	(UNIGRAINS)	(AJINOMOTO)	**Average**
Wheat	1 749	3 594	1 838	**2 394**
Maize	618	403	567	**529**
Barley	1 428	806	1 768	**1 334**
Other cereals	27	-	333	**120**
Wheat by products	1 218	998	525	**914**
Peas	1 724	898	435	**1 019**
Soybean meal	3 932	3 298	4 439	**3 890**
Rapeseed meal	661	661	1 180	**834**
Sunflower meal	64	-	643	**236**
Total	11 421	10 657	11 726	**11 268**
Cereals and cereals by products contribution	44%	54%	43%	**47%**

However the particularity of cereals protein, is its specific deficiency in some essential amino acids particularly lysine and threonine, when compared to pig (and poultry) requirement (fig.21). The valorisation of the protein fraction of cereals is thus conditioned by the supplementation with free amino acids, which allow to complement the unbalanced amino acid profile of cereals.

fig. 21 Digestible amino acid profile, % pig requirement



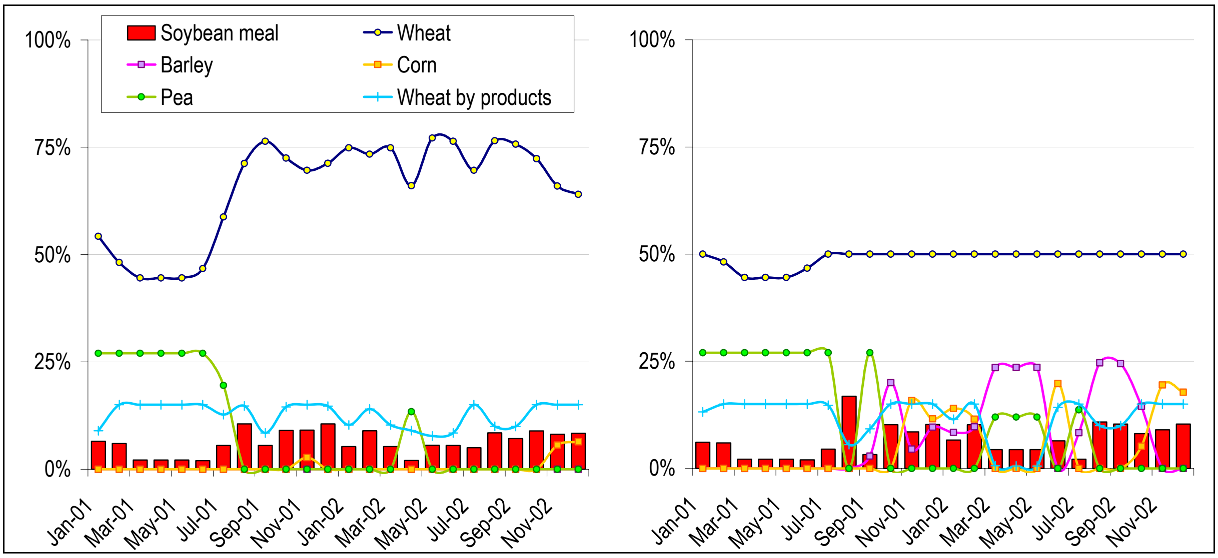
7.2 Factors impacting cereal usage

Furthermore, in order to forecast what could be the contribution of cereals to global protein supply in the near future, we propose to overview which factors impact cereal usage in pig diets. This has been studied by mean of least cost feed formulation simulations (Unigrains model), according to different prices conjuncture over the last two years (i.e. since the suppression of meat meal in feed formulation, see fig.20 for wheat and soybean meal prices levels). Even though the highest historical prices are not reached, the prices of soybean meal are rather different over this period with a decreasing tendency; the ratio between the prices of wheat and maize is rather steady over this period varying between 1.0 in January 2001 and 0.9 during the summer 2002. The growing-finishing pig formulas considered for these simulations had a digestible lysine level set at 7.7 g/kg feed (standardised digestibility), a digestible threonine level set at 4.7 g/kg (a level rather on the low side when compared to INRA recommendations), a crude protein level set between 150 and 170 g/kg and a net energy required level set at 9.6 MJ/kg. The criterion considered are the inclusion rates of wheat and other cereals in the diet. The main hypothesis tested are :

- the limitation of wheat inclusion rate,
- the availability of free amino acid (threonine) at a competitive price,
- the improvement of wheat protein content and
- finally the settlement of minimum or maximum protein constraints.

Special attention was paid on threonine as it is one of the critical limiting amino acid in cereal based growing-finishing pig diets, straight after lysine.

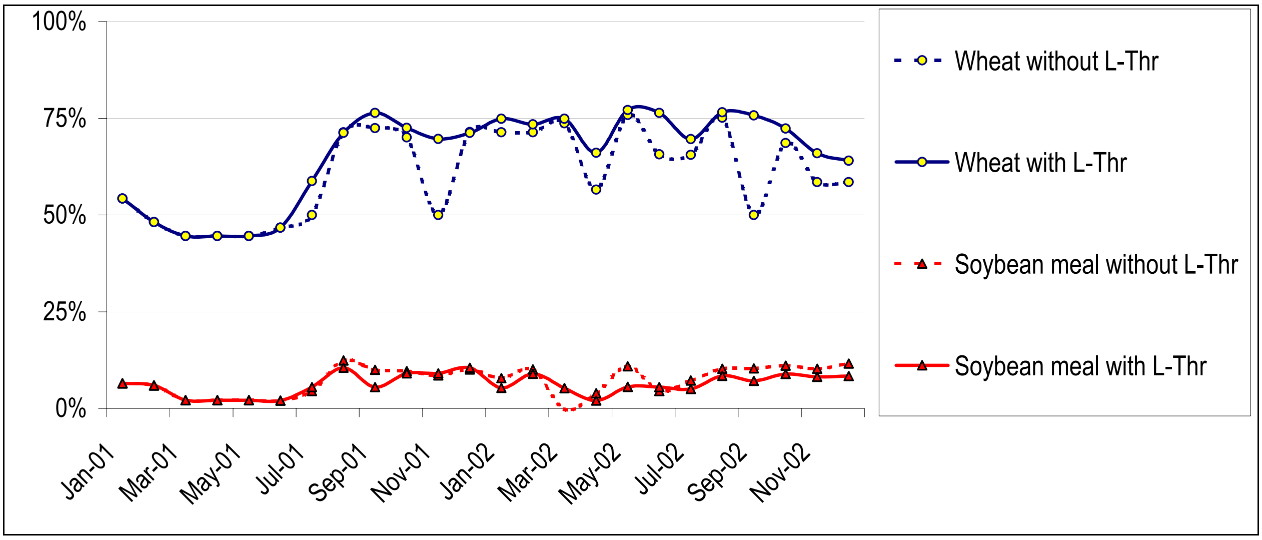
fig. 22 Feedstuffs inclusion rates across the past 2 years, as assessed through UNIGRAINS feed formulation simulations (on the left hand side without any maximum on wheat inclusion rate, on the right hand side with a 50 % maximum constraint on wheat inclusion rate).



Compared to the initial situation where wheat is not limited in the diet, and feed grade amino acids are fully available (fig.22), the restriction of wheat inclusion rate to 50% results to an increase of barley and occasionally maize in the diet, whereas few changes occur in the soybean meal inclusion rate. Such a hypothesis was tested as a recent survey performed at French feed compounders level revealed that some of them limit wheat inclusion rate in their formula in order to diversify the raw ingredients in the diet. It is however likely that higher levels are now set according to wheat price changes.

The restriction of threonine availability at competitive market price restricts wheat incorporation to the benefits of soybean meal (fig 23). This demonstrates that free amino acids are an important factor to balance amino acid profile of cereals and benefit to an extended usage of cereals.

fig. 23 Impact of threonine availability restriction on feedstuffs incorporation



We also study whether an improvement of wheat crude protein content can impact its use in pig diets. Such an increase can be achieved by different ways such as genetic improvement, more efficient fertilizer management, selection of batches with a higher crude protein content. An increase of crude protein content of wheat from 11 to 13% (with the appraisal that amino acids increase proportionally) also leads to enhanced inclusion of cereals: wheat when not limited, barley in other cases. Again, all these substitutions are made at the expenses of soybean meal.

Besides looking at feedstuffs impacts, the influence of feed protein constraints was also addressed in these simulations. Initially formulations were made with crude protein level set between 15 and 17%. When free threonine is available, the feed protein level adjusts at the minimum proposed level. The release of such a minimum crude protein content, leads to a further reduction of feed protein level induced by an increase of cereals incorporation at the expense of soybean meal and also cereal by products. An increase of free amino acids usage is then observed at the same time, to maintain amino acid balance in the diet. In absence of any constrained minimum level, feed protein level settles around 14% which can be considered as realistic from the nutritional standpoint. On the other hand, studying the impact of a maximum protein level it appears that such a practice is conditioned by threonine availability.

7.3 Cereal usage and nitrogen output

From the reference formula issued from the Unigrains simulation model, we looked at the impact of cereal inclusion rate on the nitrogen output by pigs. An increase of cereal and cereal by products inclusion rate by 5%, at the expenses of peas and oil seeds meals, result in a decrease of protein content of the diet from 15 to 14 %. Adversely a contraction by 5% of cereals and cereal by products tonnage raises feed protein level by roughly one point.

It is documented from literature that a 1%-point decrease of dietary crude protein content results in a 10% decrease in nitrogen output. It can thus be considered that any 5% increase of cereal in the diet is equivalent to a 10% decrease of nitrogen output (tab.11).

tab.11. Consequences of cereals inclusion rate in pig feed on nitrogen output by pig farms

		Reference formula		Cereals + 5%		Cereals - 5%	
	Feedstuffs protein level	Inclusion rate	Protein supply and level	Inclusion rate	Protein supply and level	Inclusion rate	Protein supply and level
	% feedstuffs	% pig feed	% CP	% pig feed	% CP	% pig feed	% CP
Wheat	10.5	**48.9%**	5.1	**51.3%**	5.4	**46.5%**	4.9
Maize	8.1	**7.1%**	0.6	**7.5%**	0.6	**6.7%**	0.5
Barley	10.1	**11.4%**	1.2	**12.0%**	1.2	**10.8%**	1.1
Other cereals	9.5	**0.0%**	-	**0.0%**	-	**0.0%**	-
Wheat by products	15	**9.5%**	1.4	**10.0%**	1.5	**9.0%**	1.4
Peas	20.7	6.2%	1.3	5.0%	1.0	7.4%	1.5
Soybean meal	45.3	10.4%	4.7	8.3%	3.8	12.5%	5.6
Rapeseed meal	33.7	2.8%	0.9	2.2%	0.8	3.4%	1.1
Sunflower meal	30.6	0.0%	0.0	0.0%	0.0	0.0%	0.0
Total		96.3%	**15**	96.3%	**14**	96.3%	**16**
Drop in protein level, %-point					- 1		1
N output			**100%**		**90%**		**110%**

7.4 Conclusion

Wheat feed usage has increased drastically since the Mac Sharry reform and today cereals and cereal by products provide about 50% of pig feed protein requirement. The feed formulation study performed herein confirms the interdependence between cereals and amino acids usages in pig feed formulation and highlights their joint contribution to an improved management of protein supply to pig production and the consequent reduced nitrogen output. Finally cereal usage in pig diets could be further increased.

8.- Protein input and nitrogen output : the environmental issue

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In recent years intensification of animal production has become a serious threat to the environment, mainly in the form of ammonia emissions into the air and nitrate surpluses into groundwater. In particular, swine industry is one of the main sectors affecting environmental pollution, especially in particular areas with extremely high density. These areas sometimes have surpluses of minerals, mainly nitrogen (N) and phosphorus (P), which has therefore resulted in imbalances between input and output. In this sense, much research has been performed to quantify the impact of nutrition, genotype, housing, storage and treatment of manure and economics in relation to the environment (Jongbloed and Lenis, 1998). Several schemes of regulations have been proposed and implemented to tackle this situation.

8.1 A European concern

The first approach in EU to reduce impact of environmental pollution was held in 1979, through a meeting held in Geneva. The meeting was organised in response to rising acidification problems, already signalled at the 1972 United Nations Conference on Human Environment in Stockholm. It resulted in the signature of the Convention on Long-range Transboundary Air Pollution by 34 Governments and the European Community. This convention was the first internationally legally binding instrument to deal with problems of air pollution on a broad regional basis. Since then, seven substantive protocols have been developed concerning the financing, and evaluation of long range transmissions of pollutants in Europe and the separate control of sulphur emissions, nitrogen oxides, volatile organic compounds, heavy metals and persistent organic pollutants and their transboundary fluxes. Thus, the necessity to develop a multi-pollutant and multi-effect reduction strategy was then stressed for the first time.

Although nitrogen in oxide form is a key pollutant contributing to all the above effects, other pollutants and particularly ammonia contribute both to acidification and eutrophication, with more than 2 million tonnes reported, most of which is emitted from agricultural sources including animal production (Jagusiewicz, 1999). Therefore, ammonia emissions have also be targeted as a key pollutant in recent EU regulations. It is assumed that techniques reducing the emissions of ammonia will reduce the emissions of other gaseous substances as well.

8.2 The IPPC Directive

The latest European text dealing with pollution concern from animal production is the text released within the frame of the IPPC directive (96/61/EC). IPPC stands for **Integrated Prevention of Pollution Control**. The text handling the prevention and control of pollution from Intensive Rearing of Poultry and Pigs was released in November 2002. The here-after section aims at summarising the main points highlighted in this official text.

- **Scope of the directive**

Besides minerals output in soil and water, the IPPC text includes some assessment of ammonia emission. Furthermore, other environmental impacts are recognised in the directive too, such as increase of the greenhouse effect (CO_2, CH_4, N_2O), desiccation (groundwater use), local disturbance (odour, noise) or diffuse spreading of heavy metals and pesticides.

The scope of the directive in terms of production units is :

– 40.000 places for poultry
– 2.000 places for production pigs (over 30 kg) or
– 750 places for sows

for several and relevant farm activities such as :

– Farm management (including maintenance and cleaning of the equipment)

- Feeding strategy (and feed preparation)
- Rearing of animals
- Collection and storage of manure
- On-site treatment of manure
- Land spreading of manure
- Waste water treatment

Are considered, and the environmental issues associated with the above list are:

- The use of energy and water
- Emissions to the air (e.g. ammonia, dust)
- Emissions to soil and groundwater (e.g. nitrogen, phosphorus, metals)
- Emissions to surface water
- Emissions of waste other than manure and carcasses

Other factors such as animal welfare or microbiological emissions have been considered too in some cases.

- **Best available technique to prevent and control pollution**

Several approaches to reduce the emissions can be implemented. Techniques to prevent and control in an integrated manner pollution from intensive rearing of poultry and pigs have been reviewed and assessed in the IPPC document. In this text are defined the best available techniques (BAT) to control and minimise pollution, considering:

'Best' : It means the most effective way in achieving a high general level of protection of the environment as a whole.

'Available' : It means that are developed on a scale that allows implementation in the industrial sector under economically and technically viable conditions.

This text ranks, by order of pertinence, the best available techniques (BAT) to reduce at source (prevention) nitrogen pollution, as follows :

1. Good agricultural practices. BAT ranges from implement education and training programs for the farm staff, keep records of water and energy usage, amounts of livestock feed, waste arising and field applications of inorganic fertiliser and manure, avoiding fields when are water saturated, flooded frozen or snow covered. It should be avoided too steeply sloping fields or adjacent to watercourses. Wind direction should be considered too in relation to neighbouring houses.

2.Feeding strategies. This is probably the most widely documented topic in all of the strategies described to decreased N output and emissions. This can be achieved trough nutritional management, matching feeds more closely to animal requirements at different production stages, with the aim of decrease N input and improve the retention. This will produce a lower amount of N excreted and, hence, a lower amount of nitrates and ammonia emitted.

- *Decreasing N input*. It is the most important factor when pollution is being reduced from the source. As far as nitrogen, and therefore nitrates and ammonia are concerned, the basis to a lower output is to feed the animals according to their requirements by using successive diets (phase feeding) with lower crude protein contents. These diets need to be supported by an optimal amino acid supply from adequate feedstuffs and / or industrial amino acids (lysine, methionine, threonine, tryptophan are the ones currently available). In general, it is assessed that a 1 %-point protein reduction in the feed lead to reduction by 10% of nitrogen output without affecting performance. Many works performed during the last decade supports this, including those from Henry and Dourmad (1992, 1993), Dourmad et al. (1992, 1993), Jongbloed et al. (1997, 1998), Lenis et al. (1996), or Bourdon and Dourmad (1997). N retention increases with the supplementation of essential amino acids (Kerr and Easter, 1995) and the effect can be higher if non-essential amino acids are also supplemented (Krízová et al., 2001). This ratio between essential and non essential is optimum at 50:50 but may vary up to 70:30 without affecting N retention in low protein diets (Lenis et al., 1999) which provides a reasonable margin for the nutritionist. So, feeding animal with low protein diets (low N input) appears to be the main preventive measure which tackle nitrogen emission at source and it is one the nutritional measures recognised as BAT in the directive.

It should be highlighted that feeding low protein diet do not impair body weight gain (Latimier, 1993; Le Bellego et al., 2001) or feed efficiency (Pedersen et al., 1997) and that the higher N excretion unleash a chain of reactions that are in favour of ammonia emissions, increasing ammoniacal N in the slurry (Cahn et al, 1998), slurry pH (Kay and Lee, 1996), ammonia emissions (Cahn et al., 1998), water intake (Pedersen et al., 1997) and, hence, slurry volume (Valaja, 1998) and dry matter content (Sutton, 1999).

- *Fiber*. Its interest is increasing. In general, the inclusion of fiber influences the partitioning between faecal and ureic N, increasing the faecal:ureic ratio, because of the effect on bacterial population of the gut. Recent works shows even an additive effect between fiber (soybean hulls or sugar beet pulp) and the reducing in dietary protein (Cahn et al., 1997; Zervas and Zijlstra, 2002). Ammonia emissions can be reduced too trough a decrease in pH because of a higher content in volatile fatty acids in the slurry (Shriver, 2003).
- *Phytate*. It is related too with N excretion; low phytate corn decreases P and N excretion (Veum et al., 2001) and the use of phytase in piglets increases N absorption (Murry et al., 1997).
- *Other feed additives*. In same cases have been reported to decrease ammonia production such as probiotics (Sakata et al., 1999), increase N retention decreasing ureic N excretion in low energy diets, such as L-carnitin (Heo et al., 2000) or increasing ileal apparent digestibility of amino acids such as organic acids (Mroz et al., 2002). Sometimes urine pH can be reduced and, hence, decreasing ammonia emissions trough the use of calcium benzoate (Mroz et al., 2002).
- *Health status*. It has to be considered too to optimise the N retention. Williams et al. demonstrated in 1997 the lower needs of lysine in poor health status piglets, but recently the higher needs of other important amino acids such as threonine for the immune system under inflammatory states have been proposed (Obled, 2002).

3.**Housing systems**. The principles of BAT for housing are based on reducing emitting manure surfaces (pits), removing the manure as frequently as possible from the pit to a external slurry store, applying an additional treatment, such as aeration, to obtain flushing liquid, cooling the manure surface and using surfaces smooth and easy to clean.

4.**Manure storage**. BAT on the storage of slurry is based on the usage of tanks that withstand mechanical, thermal and chemical influences, regularly emptied for inspection and maintenance, usage of double valves and stirring only just before emptying the tank. An important BAT is to cover slurry tanks with a rigid lid, roof or tent structure or a floating cover, such as chopped straw or natural crust.

5.**On-farm manure processing**. Several alternatives of mechanical separation of the solid fraction or aerobic treatment could be considered as BAT under certain conditions.

6.**Land spreading of manure**. It is accepted as BAT the land spreading and incorporation within the next 4 to 24 h or injection to the soil (open or closed slot).

8.3 Conclusions and future prospects

The pig production sector must achieve the goal of sustainability. Environmental concerns will influence the evolution of this industry, with more strict regulations and the pressure of public opinion. All of these means new economic factors. There are several methods to prevent and control pollution, and nutrient management and mainly, low protein diets, are one the most efficient and well demonstrated techniques to achieve it. But the process should be understood as a whole and every technique related to good agricultural practice, housing, storage or land spreading should be taken in account in the future.

The only thing we can be certain of is the continued change. The future will be addressed with open mind and commitment to the environment. Swine production have to adapt to these requirements and keep on being, as in the past, one of the most dynamic sectors in animal production industry.

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9.- The opportunities offered by amino acids in practical feed formulation

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9.1 Introduction

EU directive 80/778/EC limits the maximum nitrate level in drinking water to 50mg/litre. This arises in part from concerns that nitrite, derived from nitrate, may be carcinogenic. This has led to detailed examinations of the nitrogen cycle with a view to reducing water nitrate.

The EU produces almost 70 million tons of pig feed. Assuming a crude protein content in feed of 17% then approaching 1.9 million tons of nitrogen are offered to pigs annually. Only about 33% of this nitrogen is retained by the pig (Dourmad et al, 1997) so that 1.3 million tons finds its way into soil, water and air.

Reducing the crude protein content of the feed by 1% reduces nitrogen excretion by 10% (Relandeau et al, 2000). If pig performance is to be maintained, however, feed formulations must continue to supply nutrients at tissue level in order for lean tissue growth rate to proceed unhindered.

This paper examines both the formulation of low protein feeds and the influence of feeding programmes for finishing pigs on nitrogen excretion

9.2 Feed formulation

The crude protein content of feed is simply its nitrogen content multiplied by a factor of 6.25%. As such it is of little biological significance. The pig requires essential amino acids, presented in the correct balance to one another to meet the productive purpose, be that maintenance, growth or lactation. The task of the commercial nutritionist is to present these amino acids at tissue level at “least cost”.

Many pig feeds are formulated to total lysine, methionine plus cystine, threonine and tryptophan. The inaccuracy of such a system is increasingly recognised and increases as the crude protein content of the feed is reduced.

Amino acid digestibility varies markedly between feed raw materials. Thus whilst extracted high protein soya and fishmeal have a lysine digestibility of over 90%, that for extracted rapeseed and wheatfeed are 75 and 72% respectively.

Secondly, essential amino acids are required, at tissue level, in a particular balance (ideal protein). As the crude protein content of the feed is reduced there is a point at which amino acids other than the 4 noted above will become limiting to pig growth. For low protein feeds in the UK valine and isoleucine can become limiting.

Throughout the world various energy systems are used in feed formulation. The energy actually available for growth and reproduction, net energy, is increasingly used in growing and finishing pigs and is just starting to be used for sows. Net energy is certainly the system of choice particularly when formulating low protein feeds. The efficiency of utilisation of digested energy from protein is only 50% whilst that from fat is 90% and from starch is 82%. Thus formulating to digestible energy overvalues the energy contents of feeds and raw materials high in protein.

The accurate formulation of low protein feeds therefore requires a knowledge of the essential digestible amino acid and net energy values of raw materials as well as a knowledge of the pigs requirements for these nutrients at various stages of its growth and reproduction.

tab.12. Ideal protein, standardised digestible amino acids

	Lactating sow	Gestating sow	Growing pig
M+C	55%	70%	59%
Thr	66%	75%	65%
Trp	18%	22%	19%
Ile	60%	65%	58%
Val	76%	72%	70%
Leu	112%	100%	100%
P+T	114%	100%	100%
His	40%	33%	36%

In order to examine the possibility for reducing the crude protein content of feeds in the UK a formulation exercise was conducted using February 2003 raw material costs. Feeds were formulated to standardised ileal digestible amino acids. Feeds for growing and finishing pigs were formulated to net energy using the equation of Noblet (1994). Sow feeds were formulated to digestible energy.

The amino acid balance used in this exercise is shown in table 12. Generally there is reasonable agreement in the scientific literature on the methionine, threonine and tryptophan balance. However there is relatively little data on the requirements for the branched chain amino acids. For example there is a wide variation in the valine requirements of lactating sows. In this formulation exercise a value of 76% of the lysine has been used; some research papers (Richert at al, 1996) suggest a value as high as 127%.

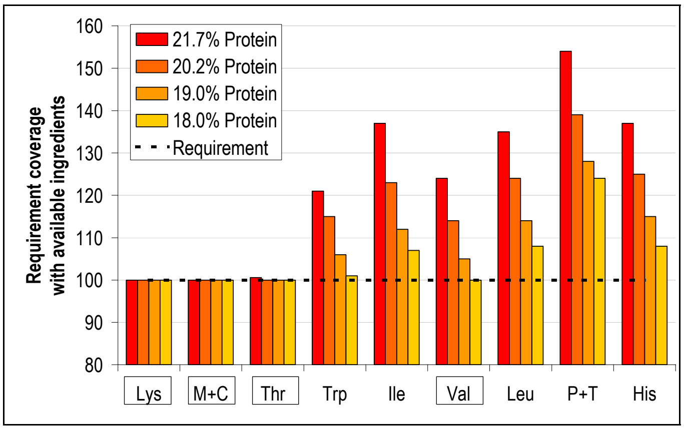
It should be noted that growing and finishing feeds in the UK are much higher in lysine and in protein then in other member states. This arises from 3 main factors. Firstly there are large premiums for lean pigs. Secondly our appetites are relatively low, as genetically the drive for lean pigs has reduced appetite. Thirdly we do not castrate our male pigs. In consequence feeds are often 20-30% higher in lysine than in many other countries.

tab.13. Growing-finishing (30-105 kg) pig diets least cost formulation
(UK type of diets, 1.0% digestible lysine per kg feed, 9.6 MJ Net energy per kg feed)

Crude protein (%)	**21.7**	**20.2**	**19.0**	**18.0**
Feed price (€/t)	137.1	135.9	136.2	139.1
Wheat (%)	42.0	50.0	50.0	34.9
Barley (%)	15.0	18.8	20.4	38.5
Peas (%)	12.2	0.0	0.0	0.0
Rape ext (%)	3.4	7.4	7.5	0.0
Wheatfeed (%)	0.0	0.0	1.9	3.6
Soya 48 (%)	24.6	20.8	16.9	19.0
Lysine HCl (%)	-	0.21	0.32	0.36
Threonine (%)	-	0.06	0.11	0.14
Methionine (%)	-	-	0.03	0.10

The specification of a high lysine finishing feed, typical of that fed in the UK to high health pigs, of good genetic merit, from 30-105kg, is shown in table 13. Formulated without crystalline amino acids the crude protein content was 21.7% and the feed cost 13.71€/100kg. Offering amino acids reduced this to 20.2% crude protein, with a little over 2kg/ton of lysine hydrochloride being used. Feed cost was reduced to 13.58€/100kg. Further reductions in crude protein increased the inclusion of amino acids and raw material cost. A formulation with 18% crude protein was achieved but further reductions in crude protein were infeasible, with the raw materials offered in this exercise, as valine became limiting (fig.24).

fig. 24 Progressive adjustment of amino acid supply to requirement by reduction of feed protein level, the case of a growing-finishing pig diet (corresponding to formulas described in tab.13)

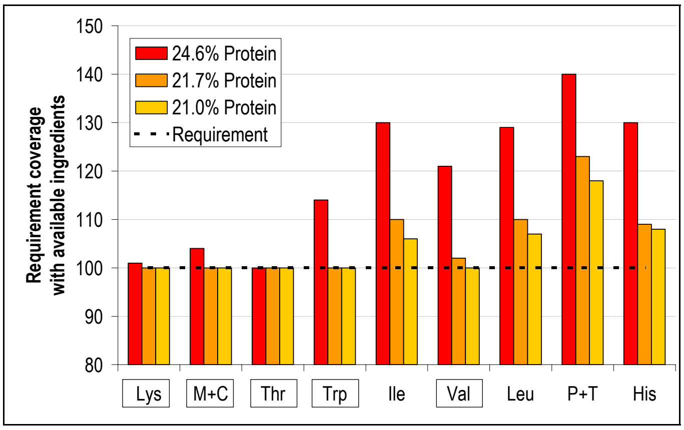


Similar exercises were conducted for a piglet feed (named grower feed in the UK, 15-30kg), a gestating and a lactating sow feed. Without added amino acids the piglet feed (tab.14), which had a digestible lysine of 1.22%, had a protein of 24.6%. With crystalline amino acids this could be reduced to 21%, saving 0.7€/100kg. Valine became limiting at crude protein levels below this (fig.25). At 21% protein the feed contained 3.1kg of lysine hydrochloride, 1.3kg/ton of methionine and 1.5kg/ton of threonine as well as 130g/ton of tryptophan.

tab.14. Piglet (15-30 kg) diets least cost formulation (UK type of diets, 1.22% digestible lysine per kg feed, 10.3 MJ Net energy per kg feed)

Crude protein (%)	**24.6**	**21.7**	**21.0**
Feed price (€/t)	190.6	173.1	183.6
Wheat (%)	40.7	44.9	16.4
Barley (%)	15	15	33.2
Maize germ (%)	0	0	15
Rape ext (%)	5	4.9	0
Soya 48 (%)	20	20	20
Fish (%)	9.4	4	5.1
Lysine HCl (%)	-	0.31	0.31
Threonine (%)	-	0.13	0.15
Methionine (%)	-	0.08	0.13
Tryptophan (%)	-	-	0.01

fig. 25 Progressive adjustment of amino acid supply to requirement by reduction of feed protein level, the case of a piglet diet (corresponding to formulas described in tab.14)

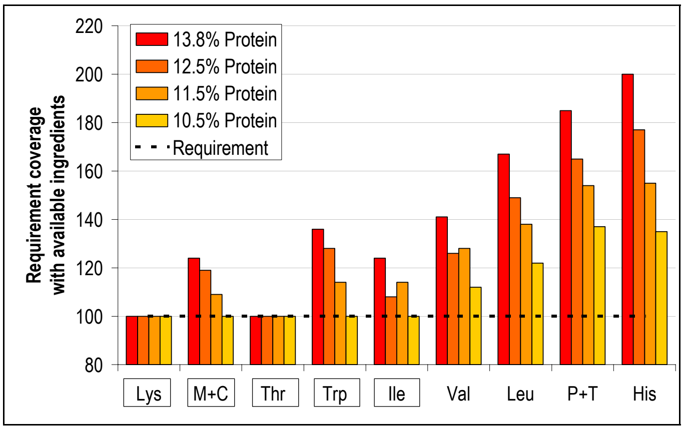


The gestating sow feed (also named *dry sow feed*, digestible lysine 0.45%) was reduced from 13.8% crude protein to 11.5% at a cost of 0.36€/100kg (tab.15). A crude protein level of 10.5% could be achieved but at a cost of 1.05€/100kg. In this case isoleucine prevented further reductions (fig.26).

tab.15. Gestating sow diets least cost formulation
(UK type of diets, 0.45% digestible lysine per kg feed, 12.9 MJ Digestible energy per kg feed

Crude protein (%)	**13.8**	**12.5**	**11.5**	**10.5**
Feed price (€/t)	100.9	100.9	104.5	115.0
Wheat (%)	49.6	55.0	55.0	38.0
Biscuit (%)	0.0	0.0	0.0	12.5
Barley (%)	0.0	3.0	23.6	28.4
Peas (%)	11.3	0.0	0.0	0.0
Rape ext (%)	1.6	0.5	0.0	0.0
Molasses (%)	0.0	0.0	2.0	6.0
Wheatfeed (%)	35.00	35.00	16.30	10.00
Lysine HCl (%)	-	0.16	0.21	0.26
Threonine (%)	-	0.05	0.07	0.10

fig. 26 Progressive adjustment of amino acid supply to requirement by reduction of feed protein level, the case of a gestating sow diet (corresponding to formulas described in tab.15)

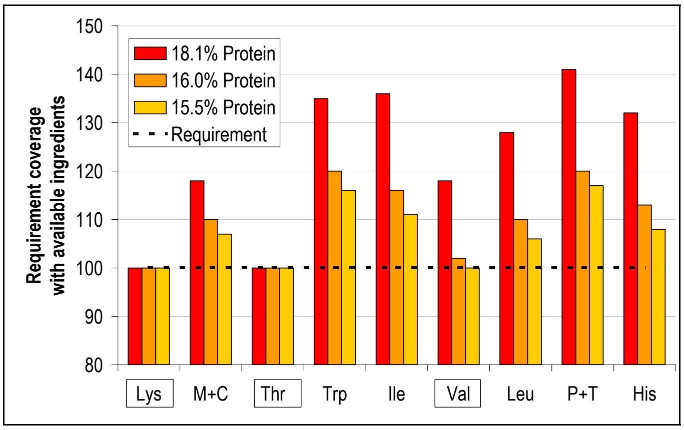


With lactating sows (digestible lysine 0.77%) crude protein was reduced from 18.1% to 15.5% (tab.16) but further reductions were infeasible as valine was limiting (fig.27).

tab.16. Lactating sow diets least cost formulation
(UK type of diets, 0.77% digestible lysine per kg feed, 13.7 MJ Digestible energy per kg feed)

Crude protein (%)	**18.1**	**17.9**	**16.0**	**15.5**
Feed price (€/t)	125.0	125.2	125.7	128.2
Wheat (%)	41.3	50.5	54.7	43.7
Barley (%)	0.0	0.0	0.0	15.2
Peas (%)	12.5	0.0	2.5	0.0
Biscuit (%)	10.0	10.0	10.0	10.0
Wheatfeed (%)	15.2	15.7	14.8	12.9
Soya 48 (%)	15.8	18.4	12.2	11.9
Lysine HCL (%)	-	0.08	0.24	0.28
Threonine (%)	-	-	0.08	0.09

fig. 27 Progressive adjustment of amino acid supply to requirement by reduction of feed protein level, the case of a gestating sow diet (corresponding to formulas described in tab.16)



From the formulation of the 4 feeds above, a simple regression can be produced defining the minimum feed crude protein achievable at a given digestible lysine content.

Minimum crude protein (%) = 12.9 * Digestible lysine (%) + 5.3 r^2=0.998

This regression is only valid for feeds offered the same raw materials, as in this formulation exercise, and at the same prices. For example offering whey, which has a high valine content, may have enabled a low crude protein to be achieved in the grower albeit at some cost. The regression may be useful however as a rough rule of thumb for those not formulating using a comprehensive digestible amino acid matrix.

Le Bellego et al. (2002) suggested that critical levels of valine and leucine in piglet feeds are likely to occur only when lysine represents more than 7% of the protein. This recommendation allows lower crude protein levels than the above regression in part as a consequence of the valine: lys ratio chosen of 68% compared to the slightly higher 70% in this study. Further the authors suggest that the valine minimum "can be treated with some flexibility until further quantification of its impact can be made available."

Within this simple feed formulation exercise for each 1% point reduction in crude protein the inclusion rate of extracted soyabean meal was reduced by almost 3%, that of cereals increased by 4% points, whilst the inclusion rate of crystalline amino acids increased by 1.6kg/ton in growing/finishing pigs, 1.4kg/ton in lactating sows, and 1.1kg/ton in dry sows.

An area for further consideration is that the vast majority of scientific literature is derived from healthy pigs. Does the amino acid balance derived from such animals accurately reflect the needs of pigs of a less healthy status? For example threonine is the major amino acid in mucins; the threonine/lysine ratio in mucins is 713% (Ball, 2001). It is also high, at 154%, in immunoglobulins compared to the ratio of 53% in carcase protein (www.ncbi.nlm.nih). This would suggest that a sick animal would require a relatively higher ratio of threonine: lysine than a healthy one.

Finally some amino acids may be "conditionally essential". Thus glutamine prevents intestinal atrophy under certain conditions. Wu et al (1996) reported that addition of 1% glutamine to a corn-soyabean diet prevented jejunal atrophy in pigs weaned at 21 days during the first week post-weaning and increased feed efficiency during the second week post-weaning.

There are many other feed factors that influence nitrogen digestion and utilisation in pigs. These include feed and raw material processing, product form, growth promoters, therapeutic antibiotics, enzymes and acids. Further reductions in nitrogen excretion can be achieved by considering such parameters.

Do low protein feeds perform? The published literature has been reviewed in detail by Bellego et al (2000, 2001). Providing that the formulations are robust then pig physical performance remains unaltered as the crude protein content of feed falls. A recent paper (Patience et al, 2002) reinforces that view.

To add a commercial dimension Premier Nutrition specified over 100 000 tons of low protein feed from June-December 2002. These formulations were 2-3% lower in crude protein that the norm for the U.K. with growing finishing feeds containing typically 3.5kg/ton of added lysine hydrochloride, and 1kg/ton of threonine and methionine. No performance problems were encountered. The general impression was that pigs up to 30kg performed better on the low protein feeds, with less diarrhoea. Feeds from 30kg to slaughter, and dry sow feeds, performed similarly. Intakes in lactation on low protein feeds were excellent. Sow condition was improved whilst weaning weight remained the same or fell marginally. It should be stressed that these are commercial impressions; there were no controls.

9.3 Feeding programmes

In the UK approximately 68% of total nitrogen excretion is from finishing pigs (30-105kg) with 46% occurring from 65-105 kg. Many UK farms still use a single feed from 30-105kg. With amino acid requirements decreasing with age this necessitates compromises. Computer simulation models suggest that by using 2 finisher feeds nitrogen excretion can be reduced by 9%, and feed costs by 1.66€/pig, without any deterioration in pig performance (table 17). The use of 3 feeds reduces N excretion by 21% with a 3.06€/pig saving. Even greater reductions in nitrogen excretion and feed costs should be available by blending "extreme" feeds on a weekly basis i.e. in this case feeds for a 30kg and a 105kg pig.

tab.17. Comparison of feeding programs : three vs two feeds vs one single feed from 35 to 105 kg

	Single feed	Two feeds	Three feeds
Feed costs	182.25	188.76 & 165.67	188.76 - 165.68 & 155.04
Feed intake, kg/day	1.88	1.89	1.92
Daily weight gain, kg/day	0.698	0.703	0.709
Feed conversion rate	2.69	2.69	2.7
P2, mm	10.9	11.2	11.5
Feed cost/pig (€/pig)	**32.19**	**30.52**	**29.13**
	100%	*91%*	*70%*
Nirogen excretion, kg/pig	**3.24**	**2.94**	**2.28**
	100%	*91%*	*70%*
Slurry nitrogen, kg/pig/year	6.91	6.26	4.86

The logic of such an approach is inescapable. However in practice performance problems have been encountered on some farms. There are a number of potential reasons for this:

- Feed intake is not accurately known
- The pig genotype, particularly the lean tissue growth curve, is not accurately defined (particularly at heavier weights).
- The effect of disease on lean tissue growth is difficult/impossible to estimate.
- Models do not currently determine the nutrient requirements and economics of a population of pigs.

Thus our models may predict that 0.95% lysine is the requirement from 60-105kg. But such a feed will be far too high a specification for the poorer gilts in the herd whilst may not be good enough for the best boars. It raises the question as to what percentage of the herd do we want to maximise their lean growth? Producers often say 100%. But this is neither economically or environmentally viable.

In practice when reducing amino acid supply to finishing pigs it is wise to move towards a theoretical target gradually, monitoring to ensure that performance does not deteriorate. Both growth rate and carcase grading are useful indicators of amino acid adequacy and are generally available on most farms.

9.4 Discussion

In the last 5 years in particular the formulation of pig feeds has become more precise with the use of standardised ileal digestible amino acids, and more recently net energy for growing pigs. Net energy for sows is now being adopted. With improved accuracy of feed formulation a reduction in the crude protein levels of feed can be achieved, with the addition of crystalline amino acids, without compromising pig performance. Indeed with the loss of antibiotic growth promoters in 2006, the likely loss of zinc oxide at therapeutic levels before then (already in force in some EU states), and ever tightening restrictions brought about through environmental legislation, low protein formulations will be increasingly preferred.

There are 2 factors that are important considerations if low protein feeds are to be more widely adopted throughout the EU.

- Firstly there are many pig feeds that are still not formulated to net energy and ileal digestible amino acids, and where the full value of crystalline amino acids are not fully recognised. This is certainly the case in the UK. In some markets a high level of crude protein is still seen as an indicator of a "quality" feed although this is now much less of a concern than say 5 years ago.

- Secondly there are economic considerations. Prices of crystalline amino acids and soybean meal have fluctuated widely in the last 2 years in particularly. Thus in the autumn of 2002 low protein feeds were very economic and in the UK over 3 kg/ton of lysine were used even in pig finishing feeds. At the time of writing this has fallen to less than 2 kg/ton because of higher amino acid prices and reductions in soya bean meal price. Price uncertainty to some extent detracts from low protein feeds. For example a feed mill may want to sell a "low protein concept" but has to be careful that the protein levels chosen and sold do not quickly become uneconomic and thus erode margin.

  In addition the financial benefits through reduced nitrogen excretion are difficult to calculate and differ for each member state, and indeed for each farm within a member state. Major financial advantages from low protein feeds can accrue on some farms through reduced water usage, slurry storage and spreading costs, and most importantly increased numbers of pigs that can be housed against a defined acreage of land for slurry disposal. In contrast an arable farm that keeps a relatively small number of pigs and is not in a nitrogen vulnerable zone may decide that low protein feeds have a negative effect on net farm profitability through a reduction in the fertiliser value of the slurry.

Low protein feeds have a marked effect on raw material usage. In the UK there are approximately 0.5 million sows and their progeny consuming some 2.75 million ton of feed. The formulation exercise suggested that for each 1% reduction in crude protein, cereal usage increased by about 4% and soy bean usage was reduced by 3%. Thus each 1% protein reduction results in an 110 000 tons/annum increase in cereal requirements with a reduction in 82 500 tons of extracted soybean meal. In this exercise the usage of the home-grown proteins, peas and rape meal, was also reduced. Pea inclusion fell with moderate restrictions to crude protein whereas rape meal inclusion fell as protein restrictions became more severe. Reductions in pea and rape prices would of course lead to an increase in their inclusion.

The use of additional feeds for finishing pigs shows obvious benefits, in terms of reducing feed costs and nitrogen output. As previously discussed there are commercial hurdles to overcome, such as limitations in the feeding equipment and often a lack of accurate farm data, as well as areas where our academic knowledge may be limiting as is the case with disease and amino acid requirements. Nevertheless a single finisher feed cannot be the most economic solution and proving that feeding recommendations are made bearing in mind such limitations, financial savings can be made and nitrogen excretion drastically reduced.

9.5 References

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10.- The role of amino acids in an environmentally friendly competitive European pig production

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The following paper aims at reviewing the past, present and possible future practices of pig protein feeding and its consequence in terms of feedstuffs usage. The analysis is built on elements collected from continuous exchanges, with, on one side nutritionists and formulators from the feed sector, and on the other side, from researchers from the various applied research institutes, with both of whom our companies work across the world towards a better understanding of amino acid nutrition.

The present review proposes specifically some quantified estimate of :

- the contribution of amino acids in sparing protein-rich-feedstuffs usage and
- the role of amino acids in decreasing feed protein level and thus nitrogen output by pigs.

10.1 The EU pig livestock, its feed requirement and protein self sufficiency

- **The European pig livestock**

tab.18. Pig slaughtering in EU and CEEC countries (Ofival 2002 from DG VI and Eurostat), in thousand tons carcass equivalent)

	1998	1999	2000	2001	2002
Germany	3 746	3 973	3 881	3 905	3 987
Spain	2 749	2 918	2 955	3 030	3 105
France	2 333	2 349	2 305	2 321	2 372
Poland	2 029	2 010	1 918	1 872	1 916
Denmark	1 698	1 709	1 677	1 739	1 814
Italy	1 330	1 391	1 401	1 405	1 444
Netherlands	1 826	1 851	1 693	1 532	1 424
Benelux	1 095	1 054	1 090	1 070	1 038
United Kingdom	1 150	1 044	901	750	709
Hungary	664	706	701	638	636
Austria	488	500	485	469	485
Rep. Czech	476	452	408	403	399
Portugal	332	324	311	289	302
Sweden	333	329	278	276	287
Rep. Ireland	251	256	233	241	254
Rep. Slov.	181	176	164	157	198
Finland	185	182	172	175	180
Greece	142	139	141	146	144
Lithuania	96	91	85	78	85
Slovenia	61	72	62	72	72
Latvia	43	40	39	35	38
Estonia	32	31	30	30	32
Total EU-15	17 658	18 019	17 523	17 348	17 545
Total CEEC	3 582	3 578	3 407	3 285	3 376
TOTAL EU-25	21 240	21 597	20 930	20 633	20 921

- **The feed requirement of the European livestock**

Assuming a carcass yield of about 77% and a feed conversion rate of about 3.1 the feed (complete feed equivalent) requirement of the European livestock can be estimated from the data presented in tab.18.

The EU-15 pigs livestock requires today about 70 million tons of feed while in the CEEC countries about to join the EU ,livestock would require about 15 million tons of feed (results are presented in table 19).

- **The European Commission's prospects**

The Commission published in June 2002 some medium term perspectives of the evolution of the agricultural markets. With some legitimate reserves they assume a 4% growth for the pig production by 2009 meaning roughly a yearly growth by 0.6% until 2009 for the present EU15 group. For the CEECs area they hypothesise also with some reserves a 16% growth by 2009.

tab.19. Calculated past and forecasted feed requirement (000 tons/year)

	1998	1999	2000	2001	2002	2004	2009
Total EU-15	71 091	72 544	70 547	69 843	70 636	71 372	73 736
Total CEEC	14 421	14 405	13 716	13 225	13 592	14 593	15 709
TOTAL EU-25	85 512	86 949	84 264	83 068	84 227	85 966	89 445

As a whole the feed amount required to grow the European livestock is not foreseen to raise much, though it is increasing progressively on a yearly basis.

The challenge consists in sourcing the required amount of nutrients, particularly protein, while on one side keeping control on feed costs and on the other side satisfying more and more stringent rules on feed safety and environmental constraints.

- **EU-15 protein self sufficiency**

tab.20. EU-15 protein self sufficiency for protein rich feedstuffs 99/00 (Unip, 2001)

	Production, thousand tons			Consumption, thousand tons			
	Feedstuffs tonnage	Protein tonnage	Feedstuffs tonnage, soybean meal equivalent	Feedstuffs tonnage	Protein tonnage	Feedstuffs tonnage, soybean meal equivalent	Self sufficiency
Soya	1 163	437	930	27 250	12 807	27 250	3%
Sunflower	3 136	499	1 063	4 729	1 371	2 918	36%
Rape	11 490	2 126	4 516	6 195	2 044	4 349	104%
Pulses	4 395	989	2 101	5 019	1 129	2 399	88%
Forrages	4 610	738	1 567	4 414	706	1 501	104%
Corn gluten feed	1 812	381	808	6 940	1 457	3 095	26%
Fishmeal	531	376	800	1 125	797	1 694	47%
Others	1 702	434	924	4 990	1 158	2 461	38%
Total	28 839	5 980	12 709	60 662	21 469	45 667	28%
Cereals				49 060	5 151	10 964	

The EU-15 protein self-sufficiency is conventionally calculated for protein rich feedstuffs only, though cereals due to their massive usage also contribute a significant amount of protein (see section 7 of the present document for more details on cereals usage). Likewise, industrial amino acids are not accounted for while they also have a major contribution to protein supply.

Nevertheless the above table which applies to the whole feed sector (all animal species) shows a protein self sufficiency of about 28% only. In other words, about 72% of the protein rich feedstuffs must be sourced outside Europe.

10.2 Principles of protein nutrition in pigs, a brief recall

- **Animal amino acid requirements**

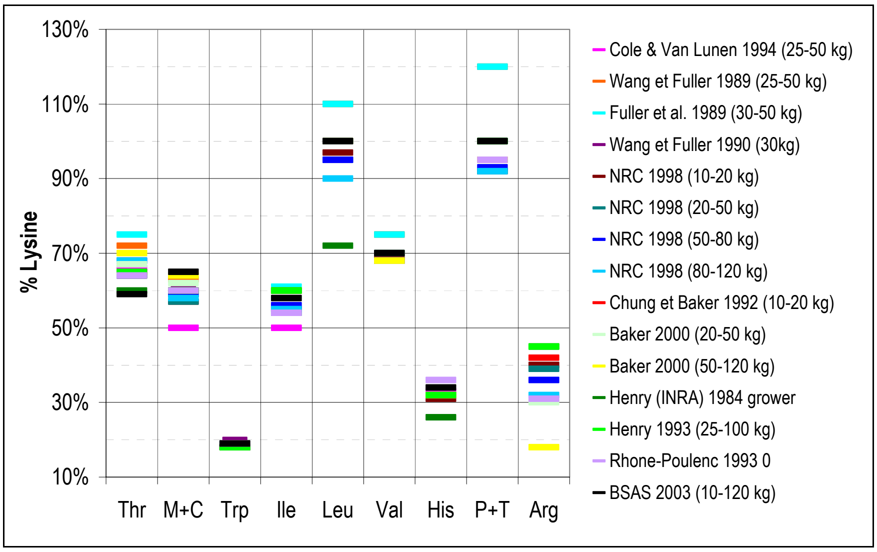
Protein nutrition consists in feeding animals with the required amounts of essential amino acids and a minimised supply of non-essential amino acids. Essential (or indispensable) amino acids cannot be synthesised by the animal and must then be supplied via the diet (while non-essential amino acids are synthesised from essential amino acids).

Body proteins are made of given sequences of amino acids. As a consequence, essential amino acids are required in given proportions in order to match the balance required for body protein synthesis. In animal nutrition, the required balance is expressed as an "ideal protein" to be fed to animals. It is usually expressed by indexing each essential amino acid requirement on the lysine required level. For example, in a conventional pig diet, digestible threonine level should represent about 65% of the lysine level to optimise protein synthesis and deposition as lean meat. Published requirements for pigs are illustrated in figure 29.

In the following study cases the French INRA recommendations (Henry 1993, 25-100 kg pigs) will be taken as a reference (Thr:Lys 65%, M+C:Lys 60%, Trp:Lys 18%), these profiles being well accepted as a minimum required levels for optimum growth. However, in practice, the implemented levels are sometimes enhanced with the aim to reach higher feed efficiency. Possible implemented levels are in such cases : Thr:Lys 70%, M+C:Lys 65% and Trp:Lys 22% in the case of piglets, or any intermediate data between these two practices.

The required levels of amino acid in pig and poultry nutrition are key, as it is those requirements which dictate the protein demand.

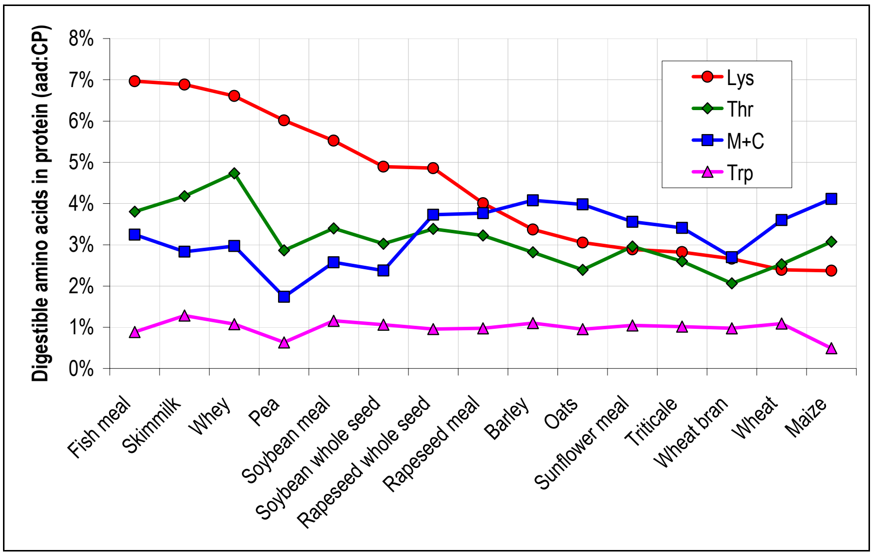
fig. 28 Published ideal amino acid balances for pigs (amino acids expressed as ratios to lysine)



- **Feedstuffs amino acid profile**

Essential amino acids are sourced from the digestible fraction of amino acids available in feedstuffs or in commercially available supplemental amino acids (lysine, threonine, methionine and tryptophan). Feedstuffs exhibit different amino acid profiles as illustrated in figure 29. As an example wheat protein contains half as much digestible lysine as soybean protein.

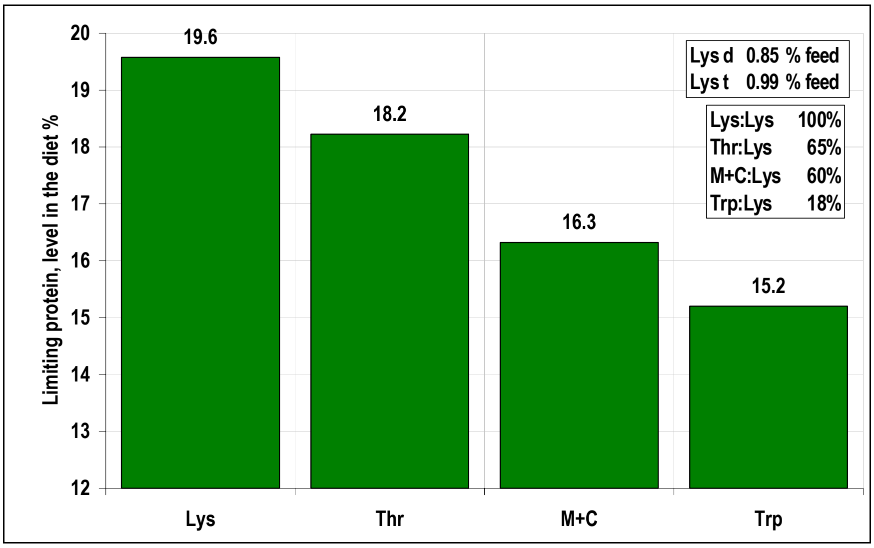
fig. 29 Digestible amino acid content in various protein sources (INRA Table 2002)



- **Feedstuffs contribution to animal amino acid requirements**

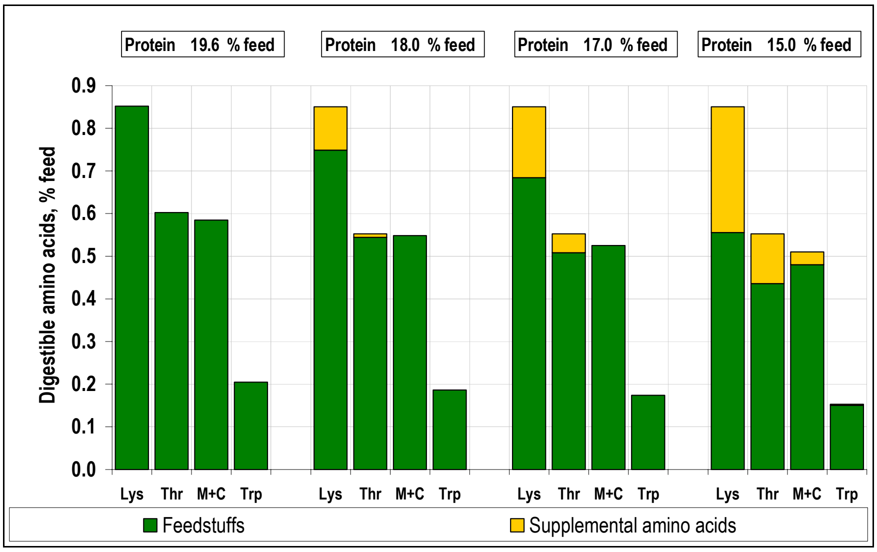
By combining animal amino acid requirements with feedstuffs digestible amino acid supply, the scheme for amino acid feed formulation can be defined. Figure 30, using an average pig feed formula (further described in table 21) with a given set of feedstuffs, illustrates the protein level at which each amino acid becomes limiting, without the use of supplemental amino acids. For example, one can deduct that if no supplemental lysine is used, the feed must contain above 19.6% protein to cover the lysine requirement, or as a second example, the formulation of a 16% protein feed requires a supplementation with lysine, threonine and methionine. A similar approach is developed by another author in the section 9 of the present document.

fig. 30 Protein levels at which each amino acid become limiting in absence of any amino acid supplementation (with ingredients selection as described in tab.21)



Amino acids supplementation is then driven by the protein level of the feed. The lower the protein level, the lower the protein rich feedstuffs inclusion and the higher the required supplemental amino acids. On figure 31, the supplementation pattern for each of the main essential amino acids in pig nutrition is illustrated, for 4 different protein levels.

fig. 31 Source of amino acids in 4 feeds differing by their protein level (with ingredients selection as described in tab.21)



10.3 Feedstuffs used today to cover pigs protein requirements

- **An average European pig feed formula**

In order to describe how pigs' protein requirements are covered by the various feedstuffs used in feed formulation, an average European pig feed formula is proposed.

The proposed formula is modelled to average the different European practices, though actually feed composition is variable and depends on various aspects such as: local commodity prices and volumes, quality of feed, environmental constraints or nutritional concepts implemented (digestible vs total amino acids, net energy vs metabolisable or digestible energy…). Thus, the formula proposed in table 21 roughly integrates :

- the various European practices in terms of nutrients levels (growing-finishing pig formula have lysine varying from 0.75 % to 1.15 % while protein levels vary from 14% up to 18%) and in terms of ingredients selection (wheat, barley and corn based diets as well as various sources of oil meals) and,
- the various types of pig feed, from piglet (hence the minor inclusion rates of dairy and fish products, for example) to sow feed, with emphasis on growing and finishing pig diets, as they represent the biggest pig feed tonnage.

The "protein" characteristics are the following :

- Digestible lysine level is set at 0.85% of the feed, corresponding to a total lysine level of around 1% of the feed.
- The amino acid balance follows the previously mentioned INRA ideal protein pattern (Thr:Lys 65%, M+C:Lys 60%, Trp:Lys 18%, digestible basis)
- The protein level is set at 17%.

tab.21. An average nowadays modelled Western European pig feed formula and consequent feedstuffs usage (Estimated European feed usage from UNIP Feb 01 reported in SYNCOPAC 2001)

	Feed formula	Feedstuffs usage, million tons	Feedstuffs usage, % European feed usage	Estimated European feed usage, million tons
Soybean meal	14%	9.8	36%	**26.8**
Rapeseed meal	5%	3.5	58%	**6.0**
Sunflower meal	3%	2.1	46%	**4.6**
Soybean whole seed	1%	0.4	25%	**1.4**
Rapeseed whole seed	1%	0.4	38%	**0.9**
Pea	3%	2.1	39%	**5.4**
Wheat	25%	17.7	45%	**39.0**
Maize	10%	7.0	24%	**28.6**
Barley	25%	17.5	56%	**31.0**
Triticale	4%	2.8	40%	**7.0**
Oats	1%	0.4	7%	**5.0**
Wheat bran	5%	3.5	32%	**11.0**
Skimmilk	0.1%	0.1	6%	**1.2**
Whey	0.1%	0.1	14%	**0.5**
Fish meal	0.1%	0.1	14%	**0.5**
Fat	-			**-**
Premix	4%	2.8		**-**
Total	100%	70.0	41%	168.9

L-Lys HCl	0.212%	0.149

- **The contribution of supplemental amino acids to pig protein supply**

From the amino acid nutrition standpoint, wheat supplemented with amino acids (lysine, threonine, methionine) is equivalent to soybean meal.

Wheat + supplemental amino acids ⇔ soybean meal

By applying different soybean meal and wheat inclusion rates to the formula described in table 21, the formula characteristics reported in table 22 are obtained.

A, B, C and D cases can be considered as historical cases.

- A : in absence of any supplemental amino acids (before 1980)
- B : before CAP 92 situation,
- C : current situation (full formula described in tab.21)
- D : near future situation

Nitrogen output in cases B, C and D are compared to the output in case A, using a 10% nitrogen output reduction per point of dietary protein decrease (IPPC study, see section 8 of the present document for more details).

tab.22. Estimated impact of feed protein level on feedstuffs and amino acid usage and consequent nitrogen (N) output by pigs

	A	B	C	D
Protein in feed, % feed (Nx6.25)	19.6	18.0	17.0	15.0
Ingredients inclusion rate, % feed				
Wheat	18%	22%	25%	31%
Soybean meal	21%	17%	14%	8%
L-Lys HCl	0.00%	0.13%	0.21%	0.38%
Ingredient usage				
Cereal usage, million tons	40.1	43.3	45.3	49.3
Soybean meal usage, million tons	15.0	11.8	9.8	5.7
L-Lys HCl usage, 000 tons	0	90	150	260
N output reduction	**0**	**-16%**	**-26%**	**-46%**

The above table summarises amino acid usage by reporting the lysine usage only, for simplification purpose. Actually, threonine and methionine supplementation are required together with lysine to formulate a balanced growing-finishing pig diet. Today, tryptophan usage is still restricted to piglet feed up to 25 kg due to its limited availability.

- **Equivalence between supplemental amino acids and soybean meal usage**

By using the data reported in table 22, the soybean meal sparing effect of supplemental amino acids can be quantified by regressing the soybean meal usage from the amino acid usage.

Soybean usage (millions tons) = -0.034 x L-Lys HCl usage (thousand tons) + 15

Here again L-Lys HCl is meant there as a tracer of the whole range of supplemental amino acids (Lysine, Threonine, Methionine and Tryptophan).

The here-above equation means the following :

100 000 tons L-Lys HCl, and associated supplements of threonine and methionine
⇔
3.5 millions tons soybean meals

- **Cereals extended usage is conditioned by amino acids utilisation**

More than 10 years after the reform of the Common Agricultural policy and its impact on cereals pricing, cereals represent today a major ingredient for the feed sector, volume-wise and quality-wise.

Since the early eighties, cereals inclusion rates in feed has more than doubled in many European countries (fig.32). As a consequences, even if cereals contain 3 to 4 times less protein than oil meals their present inclusion rates in feed formula make them a significant protein contributor.

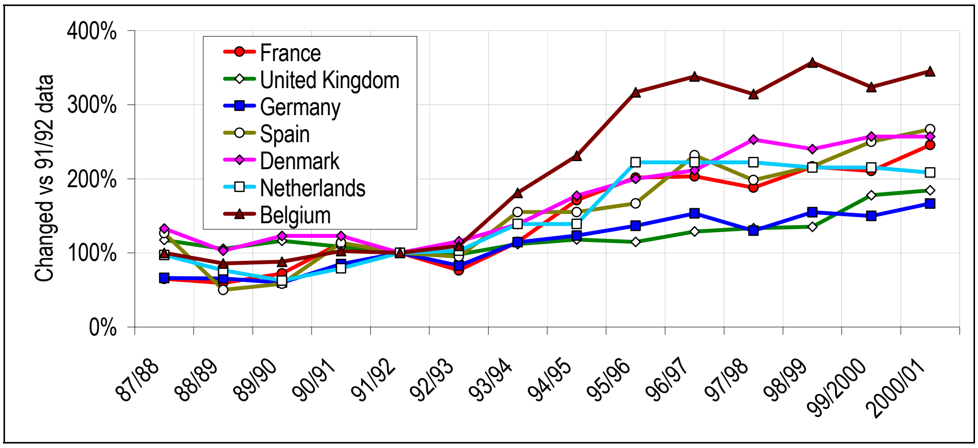
However as mentioned earlier the specificity of cereals protein, particularly for wheat and barley, is their deficiency in lysine and threonine. As a result, cereals can be valued in pig and poultry diets only when associated to the required amounts of supplemental amino acids.

By using again the data reported in table 4, the extra cereals usage allowed by supplemental amino acids can be estimated :

Cereal usage (millions tons) = +0.035 x L-Lys HCl usage (thousand 000 tons) + 40

(L-Lys HCl is meant there as a tracer of the whole range of supplemental amino acids : Lysine, Threonine, Methionine and Tryptophan).

fig. 32 Estimated total cereal consumption by the animal feed industry (all species, fefac.org)



- **Estimated contribution of amino acid usage to protein consumption**

Using the above equation (100 000 tons L-Lys HCl & combined other amino acids ⇔ 3.5 million tons soybean meals) and applying it to the current estimated feedstuffs usage in EU-15 for pigs the following table (tab.23) and graph (fig.33) can be deducted. This simplified but robust modelled approach highlights the contribution and future potential of industrially produced supplemental amino acids to the European protein supply.

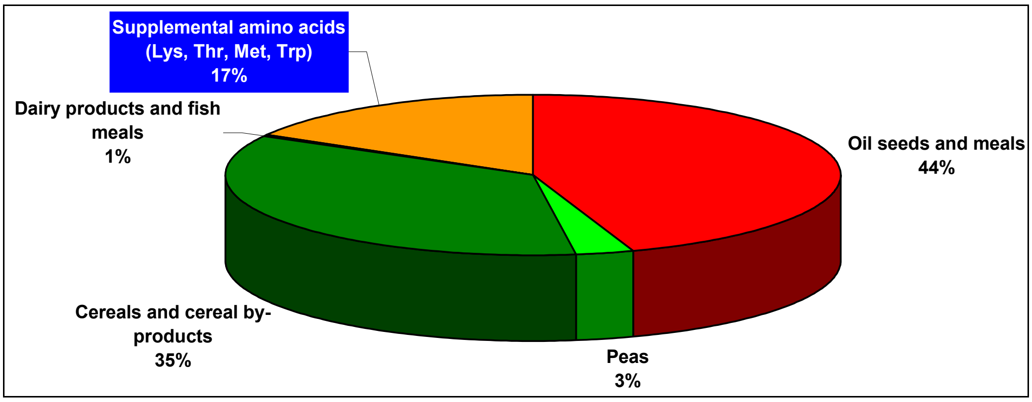
In the years 2001/2002, supplemental amino acids represented 17% of the European pig feed protein supply.

tab.23. Feedstuffs contribution to European (EU-15) pig protein supply (calculated, basis 2001/2002)

	Million tons	Protein, % feedstuffs	Protein, millions tons	Contribution to protein supply: Without accounting for the soybean meal spared by supplemental amino acids	Contribution to protein supply: Accounting for the soybean meal spared by supplemental amino acids
Soybean meal	9.8	45%	4.4	37.2%	31.0%
Rapeseed meal	3.5	34%	1.2	9.9%	8.3%
Sunflower meal	2.1	28%	0.6	4.9%	4.1%
Soybean whole seed	0.4	35%	0.1	1.0%	0.9%
Rapeseed whole seed	0.4	19%	0.1	0.6%	0.5%
Pea	2.1	21%	0.4	3.7%	3.0%
Wheat	17.7	11%	1.9	15.6%	13.0%
Maize	7.0	8%	0.6	4.8%	4.0%
Barley	17.5	10%	1.8	14.9%	12.4%
Triticale	2.8	10%	0.3	2.3%	1.9%
Oats	0.4	10%	0.0	0.3%	0.2%
Wheat bran	3.5	15%	0.5	4.4%	3.6%
Skimmilk	0.1	34%	0.0	0.2%	0.2%
Whey	0.1	10%	0.0	0.1%	0.0%
Fish meal	0.1	65%	0.0	0.4%	0.3%
Premix	2.8	-	-	0.0%	0.0%
Total	70.0	17%	11.9	100%	
Supplemental amino acids*					
L-Lys HCl	0.149				
Soybean meal equivalent	5.21	45%	2.36		16.5%
Total			14.3		100%

** Protein equivalent of supplemental amino acids, calculated based on volume of soybean meal effectively replaced (150 000 tons L-Lys HCl saves 5.2 million tons soybean meal)*

fig. 33 Feedstuffs contribution to pig feed protein supply in the years 2001/2002

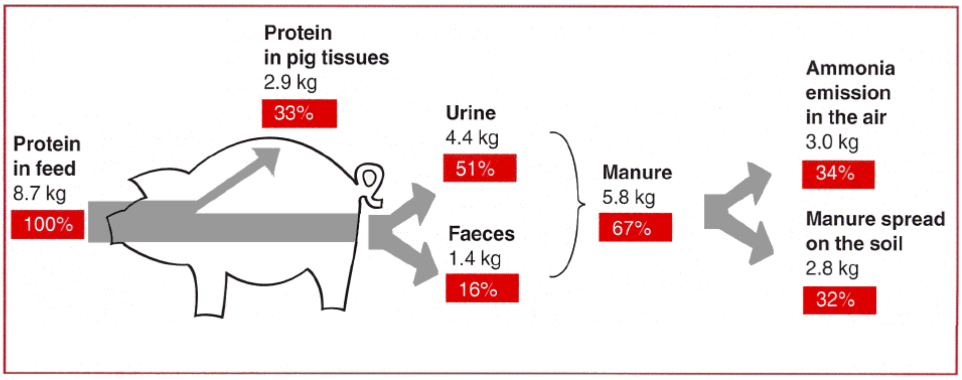


10.4 Protein input and nitrogen output : the environmental issue

- **Protein utilisation by pigs**

A large fraction of the protein consumed by pigs is excreted as nitrogen (in the manure and as gaseous emissions) after the digestion and the metabolisation process. Only a given quantity of the protein intake (about 30%, fig.34) is effectively retained by the animal for protein synthesis while the rest is released in the environment. Nitrogen in the manure is partly of value as a fertilizer, but excesses accumulate in the soil, air and water.

fig. 34 Consumption, utilisation and losses of protein in the production of a 108 kg-Pig (IPPC 2002)



- **Feeding low protein diets to minimise nitrogen output**

Following the MacSharry reform of the Agricultural policy in the early 90's, researchers and technicians of the feed sector have intensively studied the techniques to make better use of cereals in pig diets and thus have collected a broad knowledge on how to formulate high performing low protein diets.

Those feeds allow similar growth performance and carcass leanness (as long as the animal receives the proper amount of essential amino acids), while they generate less nitrogen output. It can be demonstrated that a 1%-point reduction on feed protein level leads to a reduction by 10% in nitrogen output.

- **The feeding measure : a pertinent preventive technique**

The environmental interest of such practice (reduction by 30% of nitrogen output) was acknowledged by a group of European experts as the best available technique to reduce nitrogen pollution from pig production in a preventive and controlled manner in a document released by the European Commission (Integrated Pollution Prevention and Control, IPPC, Nov 2002, 96/61/EC).

Such a potential for nitrogen output reduction (with investment in facilities) makes the feeding measure (low protein amino acid supplemented diets), the best available preventive technique to curb nitrogen pollution, far ahead of storage, manure processing and building adaptations.

- **Nitrogen production per pig depends on pigs protein rich feedstuffs consumption**

The corollary of the possible N-output reduction made possible by feeding animals with reduced protein content is that there is no such figure as a fixed quantity of nitrogen produced per pig per year. Sensitivity studies are pertinently proposed in a document released by the European Commission (ERM/AB-DLO 1999, tab.24).

The amount of nitrogen output per pig is then highly driven by the nitrogen intake or, in other words, by the protein level in the diet. Pigs consuming a 15%-protein diet (roughly 8% soybean meal inclusion rate in feed) will excrete 20% less nitrogen than pigs consuming a 17%-protein diet (roughly 16% soybean meal).

Furthermore, besides highlighting the impact of feed protein or its nitrogen content, this sensitivity emphasises also that every measure heading towards a higher feed efficiency decreases the nitrogen output per pig. The more efficient the feed, the lower the environmental load per animal.

tab.24. Impact of feed protein content and feed efficiency on nitrogen losses in the air and manure nitrogen content, ERM/AB-DLO, 1999 *(cases A, B, C and D are the same as the ones described on table 22)*

	Case A	Case B	Case C	Case D	Case C -5% on FCR	Case D - 5% on FCR	ERM/AB-DLO example
Weight at transfer from piglet to slaughter pigs, kg	25	25	25	25	25	25	25
Liveweight at slaughter, kg	105	105	105	105	105	105	105
Feed conversion, kg feed / kg gain of pigs	**2.90**	**2.90**	**2.90**	**2.90**	**2.76**	**2.76**	2.90
Feed consumption per pig, kg	232	232	232	232	220.4	220.4	232
Rounds per year	3	3	3	3	3	3	3
Feed consumption per pig per place per year, kg	696	696	696	696	661	661	**696**
Annual weight production per pig place, kg	240	240	240	240	240	240	240
N content of feed, % feed	3.136	2.88	2.72	2.4	2.72	2.4	2.8
CP content of feed, Nx6.25, % feed	**19.6**	**18.0**	**17.0**	**15.0**	**17.0**	**15.0**	**17.5**
N content of liveweight, %	2.5	2.5	2.5	2.5	2.5	2.5	2.5
CP content of liveweight, %	15.6	15.6	15.6	15.6	15.6	15.6	15.6
N intake per animal, kg	7.3	6.7	6.3	5.6	6.0	5.3	6.5
N in products per animal, kg	2	2	2	2	2	2	2
N excretion per animal place per year, kg	15.8	14.0	12.9	10.7	12.0	9.9	13.5
N losses per animal place per year, kg	**4.0**	**3.5**	**3.2**	**2.7**	**3.0**	**2.5**	**3.4**
N in manure per animal place per year	**11.9**	**10.5**	**9.7**	**8.0**	**9.0**	**7.4**	**10.1**
Reduction in N in manure, % Case A	0%	-11%	-18%	-32%			
Reduction in N in manure, % Case C					-7%		
Reduction in N in manure, % Case D						-8%	

10.5 Conclusions

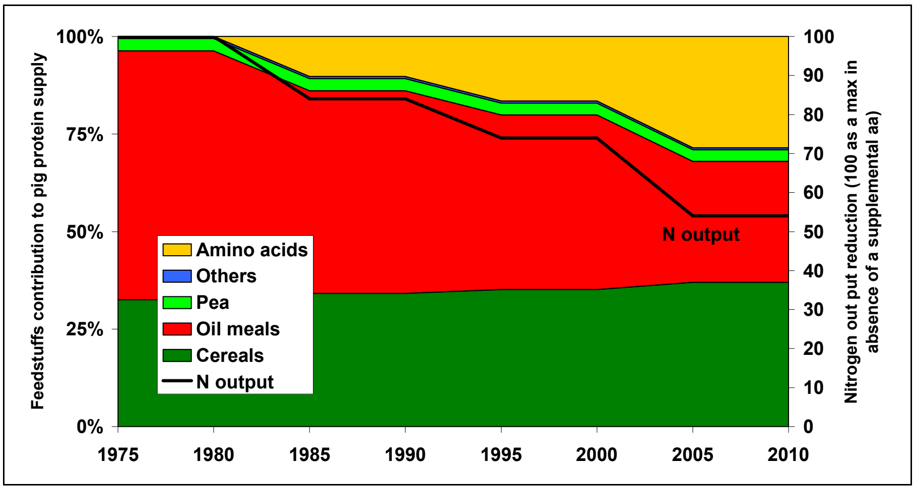
Today, supplemental amino acids (lysine, threonine, methionine and to a lower extent tryptophan) contribute very significantly to the protein supply of the European livestock.

Amino acid usage spares significant amounts of soybean meal which, besides alleviating the protein dependence of the European Union, saves some detrimental nitrogen wastage in European soils, waters and air.

Looking back at the recent history, it appears that the extended wheat usage achieved after the reform of the Common Agricultural policy in the 90's was enabled by the extra availability of these supplemental amino acids, which condition cereal nutritive value. The trend towards the formulation of lower protein feeds lead to important reductions of nitrogen output per pig even though some further progress could be reached as recommended in the latest text published by the European Commission about nitrogen pollution from pig and poultry production (IPPC, Nov 2002).

A further increase in amino acids usage is foreseen in the future, both in Western and Eastern European countries, as a result of an increased interest towards low protein diets, for both economical and environmental reasons.

fig. 35 Feedstuffs contribution to European pig protein supply, a historical overview (EU-15, amino acids are shown here as soybean meal equivalent, derived from data presented in table 22).



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