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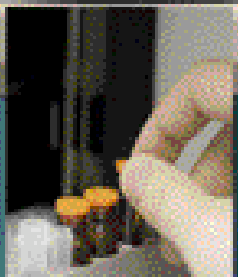
Production of Pork with Improved Nutritional and Eating Quality



Ashtown Food Research Centre

RESEARCH & TRAINING FOR THE FOOD INDUSTRY

RESEARCH REPORT NO 92

PRODUCTION OF PORK WITH IMPROVED NUTRITIONAL AND EATING QUALITY

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SUMMARY

The SUSPORKQUAL project – sustainability in the production of pork with improved nutritional and eating quality using strategic feeding in outdoor production – was designed to address issues relating to pig performance, environmental effects, meat quality, meat safety, animal welfare, nutritional quality of products, and marketability of pork from sustainable outdoor pig production systems. The project handled these issues through seven work-packages involving 11 research groups from seven European countries.

Different outdoor pig production systems, including organic, were established in various countries and used to evaluate the issues by comparison with conventional pig production systems. The effect of the feeding regimes used on the quality of pork and the impact on the environment were evaluated. Approaches to "compensatory growth" (accelerated growth rate of animals fed *ad lib* following a period of restricted feeding) were investigated as a potentially more efficient production system and one yielding improved meat eating quality. Animal behaviour and stress, as indicators of animal welfare, were assessed particularly in the context of transport of animals and the slaughtering process. The occurrence of selected chemical contaminants in pork was used to assess chemical food safety related to the pig production systems used. The meat from the various production systems was assessed for sensory quality, meat quality, technological quality and shelf-life. The nutritional value of the different pork was evaluated through human dietary intervention studies. Consumer perceptions and attitudes to different pork production systems were evaluated, together with willingness to pay for perceived improved pork quality.

The major findings from the research are the following:

(i) feeding strategies commonly used in outdoor and/or organic pig production give inferior performance, in terms of yield, compared to conventional production systems;

(ii) the compensatory feeding strategies used did not provide yields as good as conventional *ad lib* feeding strategies;

(iii) in general, conventional *ad lib* feeding production systems were found to be more sustainable in terms of efficiency of nitrogen (N) and phosphorus (P) usage compared to alternative systems;

(iv) animal welfare characteristics were better for pigs from outdoor systems and this contributes to improved meat quality;

(v) breed rather than the production system used was the most important determinant of pork quality;

(vi) no systematic differences were found between conventional and outdoor production systems in terms of chemical food safety;

(vii) strategic feeding of supplements may be used in all pig production systems to improve the nutritional value (particularly fatty acid composition) of pork;

(viii) pork in the human diet, irrespective of the pig production system used, has a positive effect on the iron and zinc absorption from the diet;

(ix) consumers have a preference for outdoor/organic pork and an expectation that such pork will be of superior quality – while consumers may be expected to pay a premium of 10-20% for such pork, that amount may not be sufficient to support the alternative pig production system.

The project has identified viable approaches for sustainable pig production systems which, while not producing pork of superior quality to that produced in conventional systems, may become more in demand because of the growing negative attitudes to conventional pig production.

INTRODUCTION

The market for food products is changing in light of consumer attitudes and requirements for higher standards in terms of quality, safety, variety and nutrition. In the case of food products of animal origin, consumers also have concerns relating to animal welfare and environmental impact. Outdoor sustainable pig production (including organic production) represents an alternative system for meat production that has the potential to fulfil consumer expectations in terms of better animal welfare, less environmental pressure and healthier products with better eating quality.

However, there are a number of significant issues that need to be addressed in order to make sustainable outdoor pig production competitive with conventional pig production and feasible. Some of the more important of these issues are whether there is poorer feed conversion and slower growth rate of pigs in outdoor production systems;

- whether there is increased output into the environment of nitrogen (N) and phosphorus (P) from outdoor production systems;
- whether there is a lower rate of protein turnover in muscle of pigs in outdoor production, resulting in less tender meat;
- whether there is an increased chemical residue content in pork from outdoor production systems related to the different feed components used;
- whether animal welfare aspects, particularly related to slaughtering, for outdoor pigs are improved;
- whether the quality of pork products from outdoor pigs is better in terms of fat composition, nutritional value and eating quality;
- whether the expected higher costs of outdoor pig production may be offset by improved market possibilities for pork products in terms of demand and price.

A multi-national project, involving scientists from Denmark, Poland, France, Sweden, Estonia, Ireland and the United Kingdom was established within the EU Fifth Framework programme to address these issues. The project, entitled "Sustainability in the production of pork with improved nutritional and eating quality using strategic feeding in outdoor production" (SUSPORKQUAL), was undertaken over the period 2001 to 2004. The project had two principal objectives, namely:

- To establish guidelines for outdoor sustainable pig production systems yielding pork with the quality characteristics demanded by current and future consumers, *and*

- To investigate the production of fresh pork and processed products corresponding to European consumers' requirements for safety, nutritional quality, improved shelf-life, animal welfare and care for the environment, while taking into account the market possibilities, consumer preferences and demand for pork in different European countries.

These objectives were addressed in the following seven work-packages, the results of the research being summarised in the following sections:

- establishment of different outdoor pig production systems in combination with feeding regimes that improve nutritional and technological quality of pork meat, and evaluation of N and P losses in different production systems;

- establishment of basic knowledge on the use of different compensatory growth approaches in pig production;

- study of animal behaviour and stress symptoms as indicators of animal welfare in outdoor sustainable production systems, compared with conventional systems, with the main focus on transport and treatment at the slaughterhouse;

- measurement of chemical residues in pigs to identify residue accumulation in pigs from different production systems;

- characterisation of sensory quality, meat quality (pH, colour, lipid composition, mineral content), technological quality (water-holding capacity, oxidative stability) and shelf-life of fresh and processed pork products from pigs in different production systems;

- evaluation of the potentially higher nutritional value of pork from pigs produced outdoors including a dietary intervention study of an exposed group of individuals (young females) who are deficient in minerals, especially iron, using pork produced in different production systems;

- definition of consumer perceptions and attitudes to different outdoor production systems in different European countries and consumer expectations of quality and willingness to pay for improved pork quality.

PIG PRODUCTION – COMPENSATORY GROWTH AND SUSTAINABILITY

Increased economic pressure on commercial pig production has led to the adoption of highly intensive production systems aimed at increasing the efficiency of the enterprise. Economic efficiency is, however, constrained by issues such as meat eating quality and animal welfare considerations. The latter issue has given rise to a consumer interest in outdoor and/or organic production of pork, involving access to roughage in addition to concentrated feed. The pig, as a monogastric animal, cannot utilise the energy and nutrient content of roughages as efficiently as ruminants. Therefore, increased intake of roughages in outdoor/organic pork production systems may have adverse effects on production performance, result in a higher environmental load of nitrogen and phosphorus, and negatively influence meat eating quality.

Compensatory growth, meaning the accelerated growth rate of animals fed *ad lib* following a period of restricted feeding, may provide more efficient production and improved meat eating quality, the latter effect due to the higher rates of protein synthesis and degradation which positively influence meat tenderness.

A comprehensive set of pig production trials was undertaken in the project to investigate production performance and sustainability (relating to environmental impact) across a range of conventional and outdoor/organic systems. Trials in Denmark that compared the performance of two breeds (Landrace and Duroc), females and castrates, in conventional and organic production systems found the following effects (Table 1):

- Organically-produced pigs, both Duroc and Landrace breeds, in general consumed more feed, grew more slowly and converted feed less efficiently than the corresponding conventionally-reared animals,

- Female pigs consistently consumed less feed, grew more slowly, had a better feed conversion and higher meat content than male castrates under *ad lib* feeding conditions, and

- Landrace pigs consumed slightly more feed, grew faster, had a more efficient feed conversion but contained slightly less meat than Duroc pigs.

Table 1: Summary data comparing performance on the basis of production system, sex and breed

System/Sex/Breed	Feed consumption (MJME/day)	Daily weight gain (g)	Feed conversion (MJME/kg gain)	Meat content (%)
Organic	34.3	960	35.8	60.0
Conventional	31.6	1024	30.9	59.4
Female	31.2	950	33.0	60.6
Male castrate	34.7	1033	33.7	58.7
Duroc	32.8	966	34.0	60.0
Landrace	33.1	1017	32.6	59.4

MJME – Megajoules metabolisable energy

Studies on the use of feed restriction and subsequent compensatory growth gave the following summary findings:

- compensatory feeding strategies did not influence production performance positively compared to *ad lib* feeding strategies;
- growing pigs have a distinct preference for concentrate feed relative to roughage, regardless of its quality/palatability;
- the compensatory feeding strategies used within the project only compensated for a portion (40-70%) of the growth retardation caused by restricted feeding and, as such, do not offer any advantage for cost-driven pig production.

In summary, the findings of these studies indicate that many of the feeding strategies commonly used in outdoor and organic production systems will result in inferior performance compared to conventional *ad lib* feeding strategies. More knowledge is required before a successful compensatory feeding strategy may be introduced, if at all, that would be attractive in terms of growth performance.

In the area of compensatory feeding strategies, a study was undertaken by Teagasc Moorepark/UCC on use of supplemental grass-meal (GM) and supplemental antioxidant (vitamin E or tea extract) in feed. The overall findings of this study indicated that feeding GM for all or part of the production resulted in depressed pig performance (expressed as either daily gain or feed conversion) and that supplementation of the diet with an antioxidant in the final stages of finishing had little effect on pig performance (Table 2).

Table 2: Effect of diet on pig performance from day 21 post-weaning to slaughter (summary data for two breeds combined)

Diet	Daily weight gain (g) (ratio)	Feed conversion
A. High density diet throughout	730[a]	2.43[a]
B. Diet containing GM throughout	675[b]	2.74[d]
C. Diet containing GM to 50kg pig weight followed by high density diet to slaughter (105 kg)	710[ab]	2.50[b]
D. Diet containing GM to 80 kg pig weight followed by high density diet to slaughter (105 kg)	686[b]	2.70[d]
E. Diet containing GM to 80 kg pig weight followed by high density diet supplemented with vitamin E	698[ab]	2.62[c]
F. Diet containing GM to 80 kg pig weight followed by high density diet supplemented with tea extract	704[ab]	2.59[c]

Values within a column with different superscripts differ significantly ($P<0.05$ daily gain; $P<0.01$ feed conversion)

Sustainability, determined in terms of dietary intake and output of nitrogen (N) and phosphorus (P), was investigated for a range of pig production systems and the following summary results were obtained:

- Conventionally-reared pigs had a lower N and P intake and excretion compared with organically-reared pigs, probably related to the lower protein contents in conventional diets;
- A high content of dietary fibre (from grass meal or alfalfa) in the diet seems to reduce the efficiency of N usage (Table 3);
- Inclusion of unsaturated fatty acids, from rapeseed oil, in the diet improved the efficiency of N and P usage;

- The lowest excretion of P was found for diets containing low levels of digestible P and supplemental microbial phytase (which reduces P output), pointing to the usefulness of this supplement for sustainability in pig production.

Table 3: Nitrogen and phosphorus efficiency observed for various production systems by different partners

Partner	Production system(s)	N efficiency (%)	P efficiency (%)
Denmark	Conventional	43.8	39.5
	Organic (various)	34.2-35.0	38.0-38.6
Poland	Conventional	36.0	40.3
	Conventional plus GM	33.9-36.1	37.7-40.4
Sweden	Conventional	34.9	31.3
	Outdoor (various)	29.7-36.2	27.3-30.5
Ireland	Conventional	36.0	55.5
	Conventional plus GM	31.1-35.0	49.9-54.9
France	Conventional	40.6	
	Outdoor	35.6	
Estonia	Conventional	41.2	39.3
	Semi-outdoor	37.1	35.4

In summary, the general picture on sustainability is that *ad lib* feeding of diets with minimised protein contents (*i.e.* using supplemental amino acids as in conventional diets) supports more sustainable pig production in terms of higher efficiency of N and P usage and, consequently, lower N and P outputs in manure from pig production systems.

PIG WELFARE - REARING, TRANSPORT AND SLAUGHTER

The effect of the pig production system on animal welfare is important in terms of the inherent quality of life for the pigs. In addition, the pig production system used may affect the behaviour of pigs, particularly during transport to and lairage at the slaughter plant. Negative or stressful behaviour may have deleterious effects also on meat quality post-slaughter (ultimate pH, water-holding capacity) and on subsequent quality of meat products.

For this work-package, two of the partners in Denmark (DMRI) and France (INRA) studied the effect of various pig production systems on animal behaviour and meat quality. The following observations were made:

- During rearing, outdoor pigs are more active and show a broader range of activities than indoor pigs, suggesting that animal welfare is better in outdoor production systems generally;

- A faster reduction in emotional and behavioural arousal (*i.e.* disturbance) occurs in outdoor pigs compared to indoor pigs during changes in the pigs' environment;

- Compared to outdoor and free-range pigs, conventionally-produced pigs are more active and take longer to settle during transport and in the lairage;

- Conventionally-produced pigs show a higher frequency of aggressive events;

- Mixing of pigs from different rearing groups during transport and especially lairage should be avoided to minimise disturbance of the pigs and to decrease the incidence of fights and skin damage; the frequency of unacceptable skin damage was generally higher in conventionally-produced pigs compared to outdoor or free-range pigs (Figure 1).

In summary, an enriched environment during rearing (as occurs in outdoor and free-range production systems) challenges the pigs positively, with

consequent better behaviour during transport and lairage. For all production systems, mixing of pigs from different rearing groups during transport and lairage should be avoided. It has been established in other studies that reduction in stressful behaviour in pigs, apart from the positive animal welfare aspects, generally improves meat quality characteristics.

PORK MEAT QUALITY - EFFECT OF REARING SYSTEMS AND BREEDS

Extensive studies were undertaken by partners in Denmark, Sweden, Ireland, France, Poland and Estonia to assess the effect of various production systems on meat quality. These studies covered sensory quality (including tenderness and juiciness), technological quality (including water-holding capacity, shear force and colour) and shelf-life.

While pork meat quality was affected by the production system used, the effect of breed on quality parameters was more pronounced. In general, pork from the Duroc breed had better sensory quality characteristics, being more juicy and tender than pork from the Landrace breed (Figure 2). Similarly, Duroc pork showed better water-holding capacity, *i.e.* lower drip loss compared to Landrace pork (Table 4). Different feeding systems affected the tenderness of Landrace loins but had no effect on Duroc loins (Table 5).

Table 4: Water-holding capacity (% drip loss) in the loin from different pig crossbreeds

Breed (sire)	France	Sweden	Denmark	Ireland
Duroc	4.2[a]	3.7[a]	6.9[a]	3.3[a]
Landrace		5.1[b]	8.0[b]	5.2[b]
Large White	5.2[b]			

Within each country, values for breeds with different superscripts differ significantly.

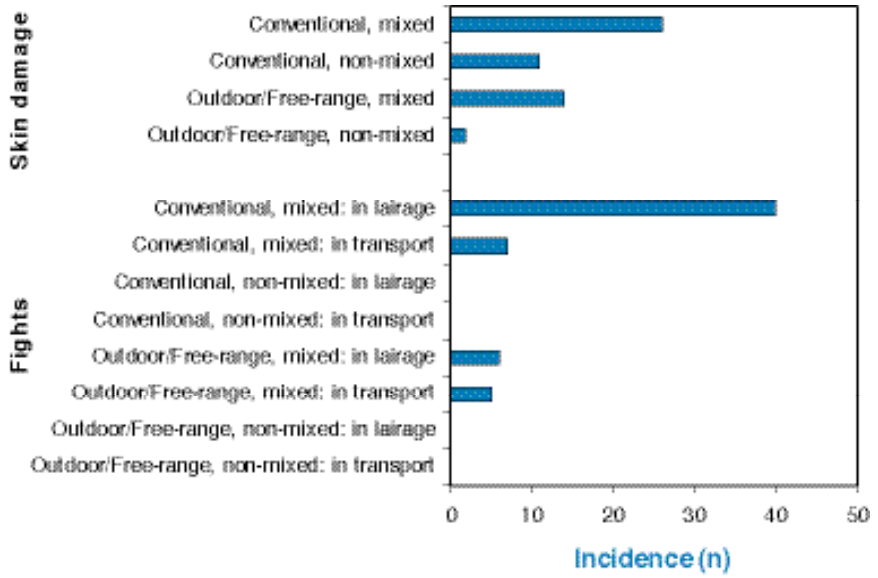

Figure 1. Incidence of fighting during transport and lairage and observed skin damage for outdoor/free-range and conventional pigs, under conditions of non-mixing or mixing (summary data).

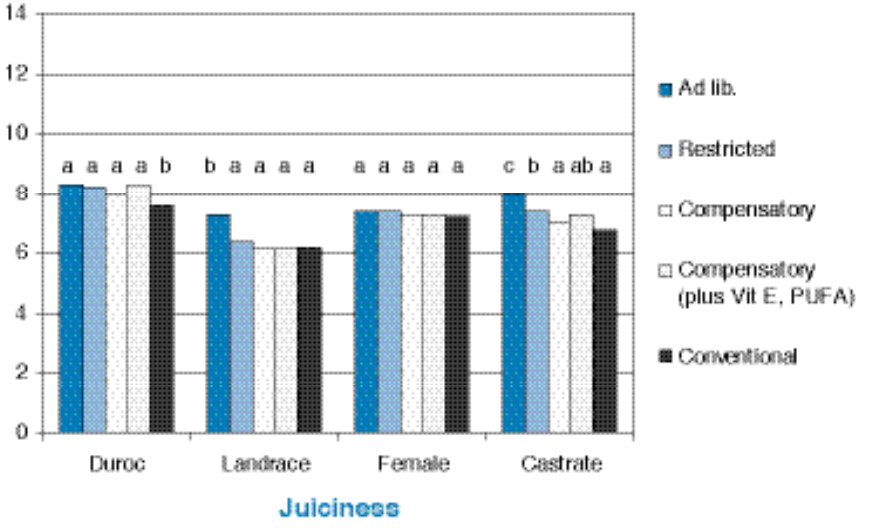

Figure 2(a). Sensory profile of Danish loin chop (Juiciness – Scale 0-15). Within each breed and sex, bars bearing different letters differ significantly.

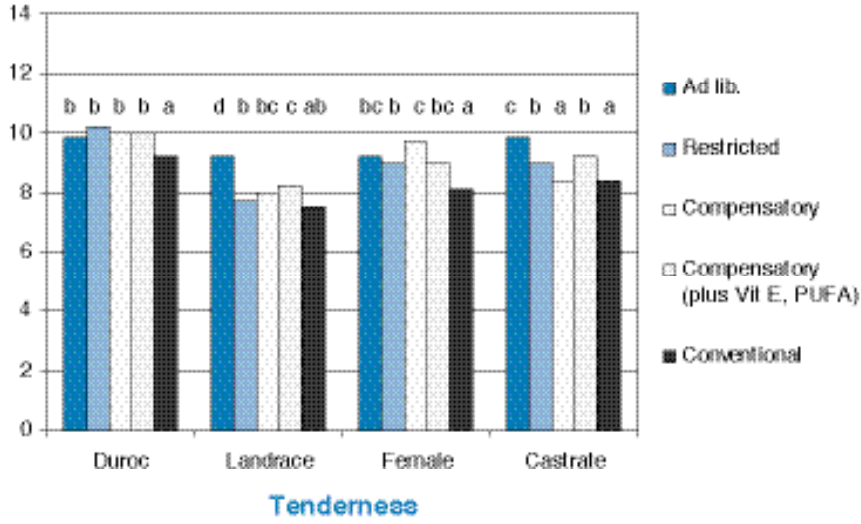

Figure 2(b). Sensory profile of Danish loin chop (Tenderness – Scale 0-15). Within each breed and sex, bars bearing different letters differ significantly.

In the case of production system, the effects on meat quality are not as marked or consistent. The following general statements may be made:

- compensatory growth, involving accelerated growth prior to slaughter, improved tenderness, as determined by shear force measurement, compared to pork from feed restricted production systems (Table 5);
- *ad lib* feeding may produce more tender and juicy meat and outdoor production may also improve sensory characteristics (depending on the feeding strategy used);
- compensatory growth does not seem to affect technological pork quality traits, such as water-holding capacity and colour.

Table 5: Warner-Bratzler shear force (N) in loin from strategically-fed Danish pigs

Rearing system	Duroc	Landrace
Control, organic	25.2	25.9[a]
Restricted, organic	22.8	36.0[b]
Compensatory 50 organic	25.4	29.0[a]
Compensatory 50 PUFA/Vitamin E, organic	24.0	26.4[a]
Conventional	25.6	34.6[b]

Within the Landrace breed, values for different rearing systems with different superscripts differ significantly.

A study by UCC/Teagasc Moorepark, using lipid oxidation (TBARS) as an indicator, found that the various production systems had little effect on shelf-life of cured pork products. Again, breed was the major factor affecting lipid oxidation in cured hams (Duroc being better than Landrace) although TBARS values for products from both breeds were relatively low (Table 6). Meat colour of cured hams was also affected by breed (Landrace being redder than Duroc).

Table 6: Effect of breed on TBARS and redness (a* values) of cured ham during storage in a modified atmosphere (70% N_2:30% CO_2) at 4^0C

	Breed					
	TBARS[1]			Redness (a* values)		
Day	Landrace	Duroc	Sig.[3]	Landrace	Duroc	Sig[3].
0	0.093 ± 0.003[2]	0.085 ± 0.002	ns	8.20 ± 1.41	5.99 ± 1.00	***
4	0.120 ± 0.003	0.087 ± 0.004	*	4.52 ± 0.78	3.22 ± 0.54	***
8	0.119 ± 0.003	0.114 ± 0.003	ns	3.76 ± 0.64	2.25 ± 0.38	***
12	0.076 ± 0.002	0.071 ± 0.003	ns	3.19 ± 0.55	2.41 ± 0.40	**
16	0.086 ± 0.002	0.058 ± 0.001	**	3.40 ± 0.58	2.34 ± 0.39	***
20	0.107 ± 0.004	0.107 ± 0.003	ns	3.10 ± 0.53	2.46 ± 0.41	ns

[1]TBARS, mg MDA/kg sample; [2]Mean values (±SEM); [3]Significance: ns = non significant,* = $P < 0.05$, ** = $P < 0.01$, *** = $P < 0.001$

In summary, the results of the studies established that the sensory and technological quality of products produced from outdoor and organic production systems may be improved through strategic choice of breed and feeding strategy. In addition, optimisation of compensatory growth might raise the quality of pork to that produced from conventional production systems. Lastly, only marginal or no differences in the oxidative shelf-life of pork products were observed in relation to production system used.

PORK SAFETY – CHEMICAL RESIDUES FROM DIFFERENT PRODUCTION SYSTEMS

In pig production, animals may be exposed to a range of potential contaminants occurring from feed and the environment. Such contaminants include agrochemicals and environmental contaminants, which may result in residues occurring in pork tissues and pork products at levels of concern to the consumer. The potential exposure of pigs produced under conventional (indoor) and outdoor (including organic) systems may be different because of the particular feeding and environmental conditions applied. For example, in outdoor pig production systems the animals have direct contact with the external environment, compared to pigs produced in conventional systems. This may lead to increased body burdens of some environmental contaminants. In the case of organic production systems, which have specifications regarding types of feed that may be used and amounts of roughage to be contained in the diet, the quantity, uptake and bioavailability of feed contaminants to the animal may be different to conventional production systems.

Three main classes of contaminants were studied in the project - heavy metals, persistent organic contaminants and pesticides, and mycotoxins. The four non-essential and toxic elements, mercury, cadmium, lead and arsenic, and the essential elements, zinc and copper, constituted the heavy metals. Dioxins, polychlorinated biphenyls (PCBs) and organochlorine and organophosphorus pesticides were chosen as representative of persistent organic contaminants and pesticides. Mycotoxins are produced by moulds often present in feed and forage and ochratoxin A, aflatoxin and zearalenone were selected for the study.

The pigs originated from experimental farms in Denmark, Estonia, France and Sweden in each of which two different production systems, conventional and out-door, were applied. Forty pigs were assigned to each production system, resulting in a total of 320 pigs being tested for chemical residues.

Heavy metals

No differences between the contents of zinc, mercury, cadmium and arsenic related to conventional and out-door production systems were found but significant differences related to country were found for these heavy metals (Table 7). The levels of these heavy metals in all samples were below the EU maximum residue limits (MRLs) of 1 ppm for cadmium and 0.2 ppm for mercury; no MRLs are set for zinc and arsenic. Significant differences were found between the lead and copper levels related to conventional and out-door production systems, and such differences were country dependent (Table 7). All samples contained lead at levels below the MRL of 0.5ppm; no MRL is set for copper.

Mycotoxins

No measurable residues of aflatoxin M1 or of ochratoxin A were determined in the samples (limits of determination = 0.02 g/kg and 1 g/kg respectively). A number of studies in the scientific literature report the occurrence of ochratoxin A residues in porcine kidney. Therefore, the results from this study, representing pigs produced in four countries by two treatments, are unexpected in that no measurable ochratoxin A was determined in any of the samples. Only in five samples were measurable residues of zearalenone or its metabolites, α-zearalenol and β-zearalenol, determined. In the case of three of these samples, the levels of zearalenone, α-zearalenol and β-zearalenol determined were at the limits of quantification for the method; 2, 2, and 20 g/kg, respectively. Two samples, both from the out-door production systems and one from Denmark and the other from France, were found to contain 4.3 g/kg and 2.6 g/kg zearalenone, respectively.

Table 7: Mean heavy metal contents (ppm) in pigs produced in conventional and out-door systems

Country	System	Lead	Copper	Cadmium	Arsenic	Zinc	Mercury
	Conventional	0.020	6.92	0.063	0.009	49.1	0.016
Denmark							
	Out-door	0.038	5.50	0.068	0.009	51.0	0.013
	Conventional	0.034	6.71	0.098	0.005	55.7	0.022
Estonia							
	Out-door	0.024	7.80	0.099	0.005	57.7	0.023
	Conventional	0.022	9.87	0.134	0.007	74.3	0.028
France							
	Out-door	0.039	8.41	0.180	0.008	73.5	0.033
	Conventional	0.024	11.32	0.076	0.006	56.3	0.018
Sweden							
	Out-door	0.027	6.93	0.088	0.007	55.4	0.016

Summary of Table

Lead: Country dependent differences between the two treatments
Copper: Country dependent differences between the two treatments
Cadmium: No differences between treatments, differences between countries
Arsenic: No differences between treatments, differences between countries
Zinc: No differences between treatments, differences between countries
Mercury: No differences between treatments, differences between countries

Pesticides

No measurable residues of organophosphorus pesticides were detected in the samples (limit of determination = 50 g/kg). Three organochlorine pesticides were determined in fat samples. p,p-DDE was determined in the samples from out-door production systems in Sweden at levels ranging between 3 and 9 g/kg (Maximum Residue Limit (MRL) = 1000 g/kg). cis-Heptachlor was

determined in some samples from the out-door production system in Denmark at levels ranging between 3 and 4 g/kg (MRL = 200 g/kg). Hexachlorobenzene was determined in some samples from the conventional production system in Estonia at levels ranging between 3 and 6 g/kg (MRL = 200 g/kg). No samples from other countries or production systems contained measurable levels of these or other organochlorine pesticides. The results for organochlorine pesticides in porcine fat indicate that certain pesticides may occur in particular production systems/countries, probably related to their occurrence in feed or the environment, but at levels much below the appropriate MRLs.

Polychlorinated biphenyls and Dioxins

The compound PCB 28 was the only polychlorinated biphenyl determined in fat samples. PCB 28 was determined at levels below the limit of quantification of 20 g/kg in 10 (of 160) samples from the conventional production systems in Denmark, Estonia, France and Sweden, and in one sample from the out-door production system in Estonia. Dioxins, expressed as total Toxic Equivalents (WHO-TEQ), were all of the order of 0.4 ng/kg fat in the eight fat samples analysed (EU maximum permitted level for pork is 1 ng WHO-TEQ/kg fat).

In summary, while interesting differences between countries/production systems were found for heavy metals and some organic contaminants, such as organochlorine pesticides, overall the levels of contaminants determined in the samples were relatively low or non-detectable. No values were found to exceed MRLs or maximum levels for any of the chemical residues.

No systematic differences of any consequence were found between pigs produced under conventional or out-door systems in the project. It is possible to conclude that pigs produced in these different production systems are broadly comparable in terms of contaminant residues. When pigs are produced under appropriate conditions, as is the case within the production systems used in the project, there is no concern relating to contaminant residues in edible tissues.

The effect of feed composition and feeding strategies on the nutritional value of pork was investigated. Fat content, fatty acid composition and mineral content were the aspects taken as representing nutritional value. In addition, studies were undertaken on the absorption of iron and zinc in young women, with low to normal iron stores, from diets with and without pork.

Intramuscular fat content of pork loin was not significantly affected by feeding strategy in most cases. Organic feeding, including roughage and feed supplemented with polyunsaturated fatty acids (PUFA), improved the fatty acid composition of pork. This improvement in fatty acid composition was demonstrated as a decrease in the ratio of *n-6* PUFA to *n-3* PUFA (PUFA *n-6/n-3*) and as an increase in the ratio of PUFA to saturated fatty acids (P/S) (Table 8). It has been suggested that this feed-induced change in the fatty acid composition of pork fat may decrease the cholesterol content, thereby reducing the risk for cardiovascular disease in humans.

Table 8: Fatty acid composition of neutral lipids in intramuscular fat of Danish pork loin

Fatty acid (%)	Feeding strategy		
	Conventional ad lib	Organic control ad lib	Organic compensatory (including PUFA/VitE)
SAFA	39.4[a]	38.2[b]	37.3[c]
MUFA	55.7[a]	54.7[b]	54.4[b]
PUFA	4.9[a]	7.1[b]	8.3[c]
PUFA *n-6/n-3*	13.0[a]	7.8[b]	5.7[c]
P/S ratio	0.12	0.19	0.22

SAFA – saturated fatty acids, MUFA – monounsaturated fatty acids, PUFA – polyunsaturated fatty acids. Within each row, values for different feeding strategies with different superscripts differ significantly.

Substantial differences in iron and zinc content in pigs from different countries were observed, thought to be due to the iron content in the feeds (Table 9). Outdoor free range production with strategic organic feeding increased the content of iron in pork by 25-33% compared with indoor organic production.

Table 9: Mineral content in pork loin (mean of all treatments within country)

	Denmark	Ireland	Poland	Sweden
Iron, mg/kg	3.8	6.8	8.2	4.8
Zinc, mg/kg	10.0	11.5	12.6	-
Selenium, g/kg	93	95	-	-

The study on absorption of iron and zinc when consuming a meat-based diet compared to a vegetarian diet was carried out by measuring the net effect on total dietary absorption of iron and zinc for females on the different diets. The diet including pork significantly increased the total iron and zinc absorption compared to the vegetarian diet. This positive effect of pork on iron and zinc absorption was not dependent on the feeding strategy used in pig production.

Considering the positive effect of pork on enhancing absorption of iron in the human diet and the fact that fatty acid composition in pork fat may be manipulated through strategic feeding, the nutritional value of pork may be used in promotion of outdoor and organic production systems where the appropriate breeds and optimal feeding strategies are used.

PORK MARKETABILITY - CONSUMER ATTITUDES TO PORK

Consumer attitudes to pork production and pork quality were determined using focus groups and questionnaires in France, England, Sweden and Denmark. The summary findings from these studies indicated that consumers

(a) prefer pork from outdoor production compared to pork from conventional production systems,

(b) prefer locally-produced pork,
(c) would like better information on pork, particularly through more informative labelling, and
(d) expect that pork produced using free-range and organic pig production systems will be of superior quality, not only in terms of animal health and welfare but also in terms of the sensory quality of the meat.

These preferences and expectations are not necessarily matched by consumers' capacity to differentiate between pork from different production systems nor, indeed, by any objective differences in the quality of pork from different production systems. Table 10 shows that there were no significant differences in sensory quality attributes between pork from pigs raised in indoor and outdoor systems (as measured by a trained taste panel) nor did consumers identify any differences in a blind test.

Table 10: Eating quality of pork from outdoor and indoor production systems (values are means (scale 0 to 10) for French panels)

		Outdoor	Indoor
	Tenderness	5.6	5.5
Trained panel	Juiciness	3.8	3.6
	Flavour	5.8	5.8
Consumer	Appreciation	6.4	6.4

A number of studies were undertaken to investigate consumers' perception of quality and willingness to pay for pork from conventional and extensive production systems; these aspects correspond with the marketability of pork from alternative production systems. The effects of label information were found to be substantially higher than the effects of actual meat type *i.e.* pork chops labelled as "free-range" or "organic" were consistently perceived to have higher eating quality than pork chops labelled as "conventional" or unlabelled.

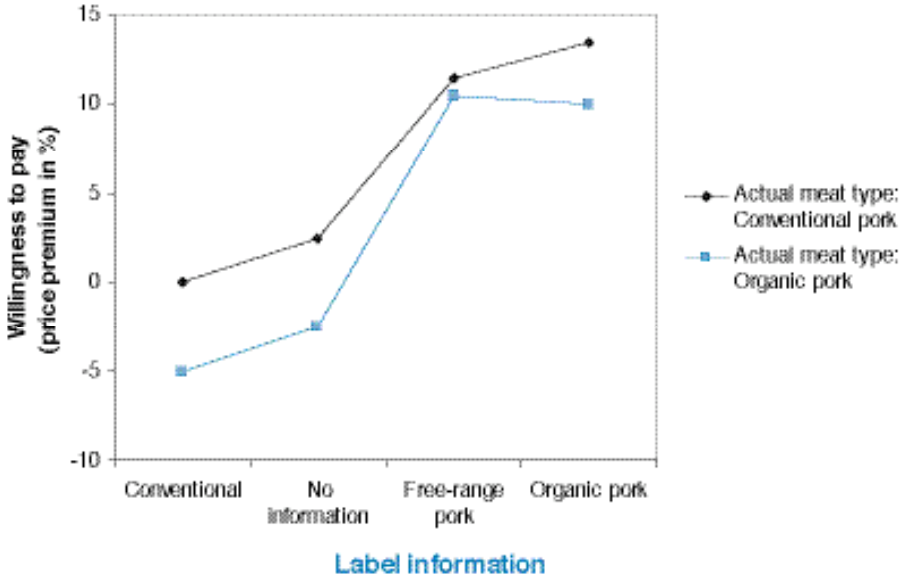

Figure 3. Maximum price premium that consumers were willing to pay for different types of actual meat under different types of information conditions (as a percentage relative to conventional pork that had been labelled as conventional pork; measured after tasting).

This perception was independent of the actual meat type tasted by the consumer and consumers were found to be willing to pay more based on such label information (Figure 3). Consumers stated that they would be prepared to pay an average premium of 12% for pork chops labelled "organic" or "free-range"; for consumers who generally favour organic foods, this premium rises to approximately 20%.

In summary, the studies indicate that there is an increased marketability for outdoor and organic pork even though a trained taste panel could not establish any real differences between outdoor and conventional pork. In fact, when differences in taste were identified, meat from conventional production systems was rated higher. It appears that outdoor/organic fresh pork is not capable of attracting a premium of more than 10-20% and, for this premium to be sustained, the objective eating quality of the pork needs to be at least as

good as that of conventional pork. To attract a higher premium, which would be necessary to ensure the economic viability of alternative systems for pig production, the intrinsic eating quality of such pork would need to be improved.

CONCLUSIONS

- In general, feeding strategies commonly used in outdoor and organic pig production systems give inferior performance to that obtained in conventional production systems.
- As currently defined, compensatory feeding strategies are not as good as conventional *ad lib* feeding strategies.
- In general, conventional *ad lib* feeding production systems are more sustainable, in terms of efficiency of N and P usage, than alternative systems.
- Outdoor-reared pigs show better behavioural traits than conventionally-reared pigs and are less prone to negative reactions under stress conditions relating to transport, lairage and slaughter.
- To reduce stress, mixing of pigs from different rearing groups should be avoided.
- Apart from the positive animal welfare benefits of reduced stress, other studies have shown that this also contributes to improved meat quality characteristics.
- The major determinant of pork quality was breed of pig rather than production system used.
- Certain production strategies, including particular types of compensatory growth systems, may contribute to enhanced pork quality from outdoor production systems.

- Overall, the effects of production systems on pork quality are marginal and inconsistent.
- Overall, the levels of contaminants, both organic (pesticides, PCBs, dioxins, mycotoxins) and inorganic (heavy metals), determined in pigs from the various production systems were low or non-detectable and no systematic differences were found between conventional and outdoor production systems.
- Where pigs are produced under appropriate conditions and receive quality feed, no concerns relating to contaminant residues in pork arise in any of the production systems studied.
- Strategic feeding of supplements may be used to improve the nutritional value of pork, particularly in the area of fatty acid composition of pork fat.
- Pork in the human diet has a positive effect on iron and zinc absorption and this effect is independent of the pig production system used.
- In general, consumers have a preference for outdoor/organic pork and an expectation that such pork will be of superior quality (even though this may not be the objective situation).
- In general, consumers may be expected to pay a premium of 10-20% for outdoor/organic pork; such a price premium may not be adequate to support economically-viable alternative pig production systems.

RECOMMENDATIONS TO INDUSTRY

One of the major challenges for this multi-country research project was how research on pig production in the various countries – differing due to local environment and production systems – could provide guidelines for sustainable pig production in Europe that would be generally applicable. However, that challenge has turned out to be a particular strength of the

project in that the knowledge gained has identified the basis for development of concepts for sustainable pig production systems that are independent of local variables.

A major finding from this project is that "wholesome" pork products need to have visible quality parameters that distinguish them from existing products so as to justify the higher product price to the consumer that is necessary to support economically-viable production. The project has identified feeding strategies that will produce pork products from sustainable production systems that have quality comparable to that achieved with conventional pig production. Nutritional value, animal welfare and choice of breed are the major factors to be promoted in the marketing of pork from outdoor or organic pig production systems.

Further research on sustainable pig production is required because of the increasing negative attitudes to conventional pig production, relating particularly to environmental and animal welfare issues. Consumer demands for locally-produced pork and traceability suggest that development of sustainable pig production systems will continue to be a priority.

While strictly organic pork production will continue to be only a niche production system in Europe because of the costs involved, such organic pork production systems serve as a good reference point for development of low input pig production systems.

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