

Quality – Growth – Balance



Pig Industry Quality Manual

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Introduction

This manual describes the systems which form the basis of Danish pork production. It is intended for buyers of Danish pork, bacon and pig meat products and others with an interest in Danish pig meat production.

Danish pork and bacon products are known and enjoyed the world over. This position has been achieved by years of dedication in all sectors of the Danish industry, in many diverse fields.

We believe that a fundamental reason behind this success has been a long term commitment to setting ourselves the highest standards, aiming to win and retain the loyalty of ever more demanding customers and their consumers.

Major investment in research and development over many years has ensured the introduction of innovative processes and products in our industry. This has also enabled us to maintain a pioneering role in the production of safe food and, at the same time, remain a competitive supplier to many international markets.

Consideration for our animals and the environmental impact of our production systems are essential elements in Danish pig production, and we are ready to assume responsibility for ongoing improvements within these areas.

We recognise the major challenges ahead, and are confident that our continuing commitment to setting the highest standards will assist us in meeting the requirements of our marketplace.

The manual describes the standard processes of Danish pig production from pig breeding to packing of the finished goods. Each section gives a description of relevant legislation and industry agreements, with a description of processes, control procedures and responsibilities.

In addition, there is a description of cross functional controls in place across the production chain. This manual represents the baseline for performance throughout the production chain, but there are instances where our pig producers, abattoirs and cutting plants operate to higher standards than those described in this manual.

It is hoped that the manual will contribute to a better understanding of the Danish pig industry and its goals, and we welcome your comments and feedback

Copenhagen, June 2010

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The Danish Pig Meat Industry and the Danish Agriculture & Food Council (Landbrug & Fødevarer)

The Danish co-operative structure, in which farmers also own the companies that process their products, provides the basis for an integrated production system. Pig breeding and production, slaughtering and processing are managed by pig producers, elected to the boards of the slaughterhouse companies. The pig meat industry is also represented on the Danish Agriculture & Food Council (Landbrug & Fødevarer), where representatives from both the pig producers and the slaughterhouse companies sit on the organisation's two boards.

As an organisation comprising farmers and the food industry, the Danish Agriculture & Food Council (Landbrug & Fødevarer) represents the entire agriculture and food chain from farm to fork. The organisation was formed from the merger of the Danish Agricultural Council, Danske Slagterier, Danish Pig Production and Danish Agriculture. The organisation also carries out activities on behalf of the Danish Dairy Board.

Denmark's food industry is of crucial importance to the Danish economy and its responsibilities extend to the persons it employs, the animals it rears, the local environment and Danish society as a whole. Agriculture and food are Denmark's largest industry and innovation grouping, employing some 150,000 people and exporting agricultural products and equipment to a value of around €15 billion.

The main purpose of the Danish Agriculture & Food Council (Landbrug & Fødevarer) is to promote the political interests of Denmark's farmers and food industry. Its strategy and activities are directed by two boards: a main board and an executive board. These jointly determine the main strategy, the activity level and financial framework of the organisation.

Environment & Energy

This division focuses on the environment and energy as well as climate policy, including the implementation of "Green Growth", the Danish government's plan for agriculture and the environment. The aim is to create a strong framework for agricultural development and growth and ensure a holistic approach, which generates synergies between the areas of climate, energy, environment and nature while, at the same time, securing sustainable and competitive agricultural production.

Research & Food

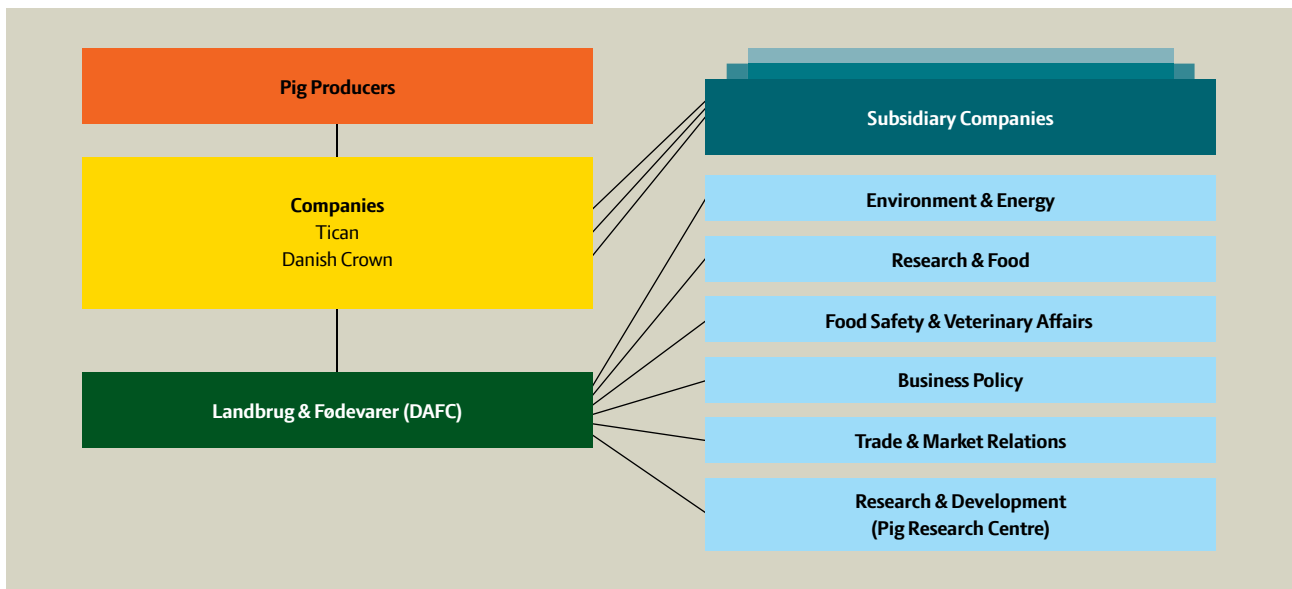
Research and innovation have high priority within the Danish agriculture and food sectors. This division focuses on research and food policy, ensuring that the industry maintains a high level of research activity in their role as providers of healthy and nutritious food.

Business Policy

The Danish Agriculture & Food Council (Landbrug & Fødevarer) works to ensure that its ideas and point of view contributes to the development of all aspects of business policy. The division is responsible for securing the best possible market environment for its members including legislation affecting co-operative affairs, the labour market as well as competition and taxation policy.

Food Safety and Veterinary Affairs

This division is concerned with veterinary issues, primarily in relation to slaughtering and meat processing. Their activities include Salmonella surveillance and provision of advice on food hygiene and food legislation. A number of their activities cover several stages of the production chain. This enables the results from official veterinary control at the slaughterhouses to improve health conditions in their supplying herds.



Trade and Market Relations

In addition to its promotional activities in Denmark and export markets, this division promotes the industry's interests in relation to trade policy, including communication to politicians, the media and other interested parties.

Research and Development

Research and development within the area of primary production is undertaken by the Pig Research Centre. The work of this division is described in Section 1.1.3

The Danish Meat Research Institute, which conducts research for the development of meat and slaughtering technology, was formerly owned by Danish pig producers, through Danske Slagterier. In order

to enhance its research, innovation and consultancy capabilities, it will merge with the Danish Technological Institute, Denmark's leading consultancy in the area of food innovation and technology on 1 October 2009. While no longer owned by the pig producers, the close partnership with the pig industry will be maintained.

1 Primary

Chapter 1 covers primary production, i.e. breeding and production of finishing pigs. It describes the structure of Danish pig production, training of personnel, dissemination of information and the pig production process. The Danish breeding programme is then outlined as well as the basis for determining breeding objectives. The important issues of animal health and welfare are described separately followed by a section on the production environment and feed production.



1.1 Structure

Within the Danish pig industry, the pig producers themselves own and control many of its key areas and activities:

- Pig breeding programme (DanBred)
- Research and development
- Pig advisory services
- Co-operative companies
- Marketing of Danish pig meat.

The industry is therefore able to develop an integrated production chain and react to customer demands. Common breeding objectives are laid down to make optimum use of the breeding potential and also improve meat quality.

Extensive research and development programmes, coupled with professionally managed production systems and feeding strategies ensure a coherent and balanced approach to the sometimes conflicting requirements in the following key areas:

- Meat quality
- Animal health
- Animal welfare
- Environmental impact
- Food safety.

Much of the research and development activity within the industry is undertaken in collaboration with government research institutes.

The results are disseminated through the industry's advisory system for pig producers and a five year training programme for new entrants to the farming industry.

The fact that producers deliver pigs directly to the same co-operative abattoir and is also a shareholder in that business, ensures a close

relationship between these two parties. The close contact between pig breeder, pig producer and the slaughterhouse company makes it possible to adapt production systems and methods at each stage of the pig meat chain.

While the industry itself has a major role in research and development and defining future strategies, the Danish authorities also have a key responsibility in their control of the production process and ensuring that all legal requirements are met.

The Danish Product Standard summarises the requirements governing Danish pig production and documents quality assurance in primary production. The standard has been implemented by all pig producers and is audited by independent bodies in accordance with the internationally recognised standard EN45011.

1.1.1 Production cycle

The pig production cycle typically involves a system based on the following stages (Figure 1):

- Service
- Gestation
- Farrowing
- Weaning
- Finishing.

Service

The service unit is designed to house the number of sows that are weaned as a group and may have additional space to allow them to remain there for four weeks after service. There is also an area for boars. The proportion of pens for sows and boars depends on whether the herd uses natural service or artificial insemination (AI). This area also houses gilts, which replace any older sows sent for slaughter.

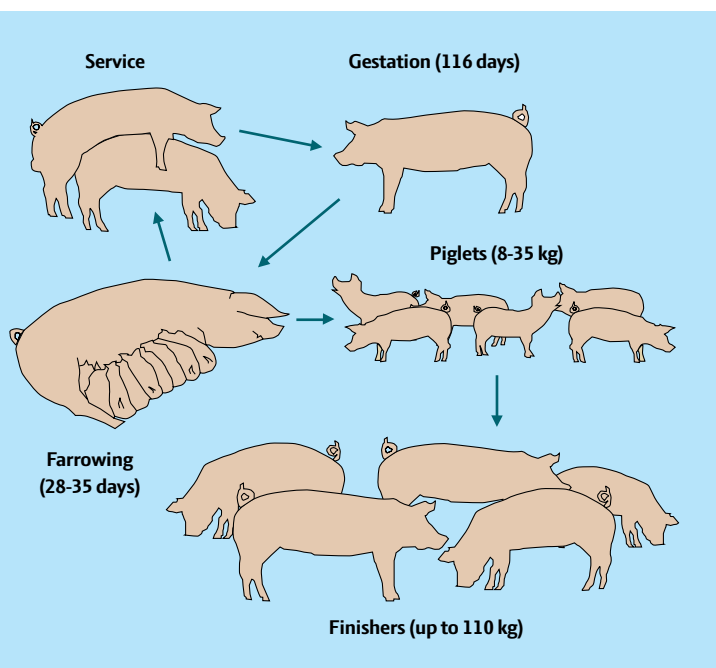


Figure 1: The pig production cycle. Service, Gestation (116 days), Farrowing/piglets (28-35 days), Weaners (8-35 kg), Finishers (up to 110 kg).

In Denmark, service units have traditionally been designed with sow stalls, but these are now well on the way to being replaced by loose systems.

Gestation

Immediately after service or following a period of four weeks, sows enter the gestation unit where they remain until around one week before farrowing. In the gestation unit, the sows may be housed individually in stalls or in groups in specially developed loose housing systems. For newly built units, loose systems are now the only housing systems permitted for sows. Around 75% of all sows are now housed in such systems.

Farrowing

The farrowing unit is based on specially designed pens, which ensure that newly born piglets are not crushed. The sows enter the unit around one week before farrowing and remain there until weaning. The time of weaning may vary but in Danish herds this is typically four to five weeks after the birth of the piglets. At weaning the sows re-enter the service area and the piglets are transferred to the weaning unit.

Weaning

The weaning unit is designed to optimise the various needs of the piglets regarding feed, climate and general environment. The normal procedure is to group pigs of similar age, so that the climate can be adjusted to their needs. The weaners remain here until they weigh 25-30 kg, after which the whole batch of pigs is transferred to the finishing unit.

Finishing

The pigs remain in the finishing unit until they reach a weight of around 100 kg, after which they are dispatched for slaughter.

1.1.2 Production infrastructure

AI: Artificial insemination - semen is purchased from a boar station or an AI station.

SPF: Many producers use specific pathogen-free (SPF) pigs. SPF represents the highest health level in Danish pig herds. SPF pigs are declared free from pleuropneumonia, mycoplasma, atrophic rhinitis, lice, mange, dysentery and PRRS. These diseases directly affect pig health but have no implications for meat quality or for human health.

The health status of all herds is determined by the presence or absence of any of the diseases above. The health status of all herds can be found at www.spfsus.dk

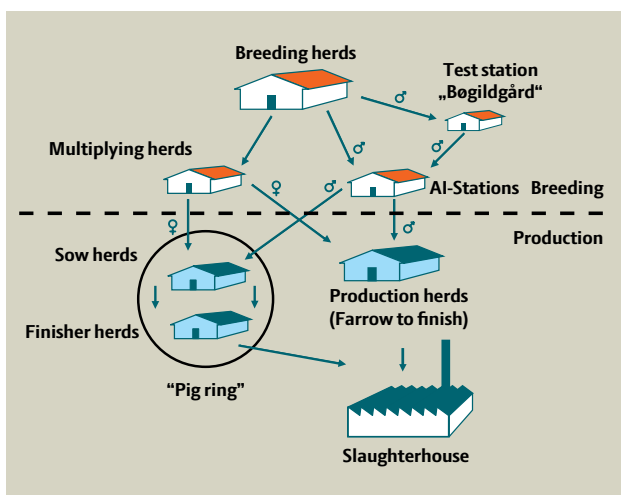


Figure 2: The structure of Danish pig meat production.

The overall structure of the Danish pig industry is shown in Figure 2

Breeding and multiplying herds

The major objective of the Danish pig breeding system is the improvement of the genetic properties of the three pig breeds Landrace, Yorkshire, and Duroc. The breeding goals are set by the Pig Research Centre (Landbrug & Fødevarer). Meat quality is an overriding consideration in the programme.

The breeding work is carried out in around 30 special herds with 16,500 purebred sows. These results are then carried forward to around 140 multiplying herds, with more than 60,000 sows producing and selling cross-bred gilts. In addition, the breeding traits are disseminated through 12 AI stations (owned by three AI companies).

DanBred is the leading producer of breeding stock and accounts for more than 95% of the breeding animals produced in Denmark. DanBred produces and sells 4,500 boars, 400,000 breeding sows, and 5.1 million doses of semen annually. In contrast to other pig producing countries, home production of breeding animals in Danish pig herds covers around 50% of requirements. This procedure has been developed to keep the herds as closed as possible for health reasons (see section 1.2.3).

All DanBred breeding and multiplying herds carry a health declaration and 98% of them are affiliated to the Danish SPF system which has been established since 1971. SPF pigs are free of production diseases such as pleuropneumonia, mycoplasma, atrophic rhinitis, dysentery, mange, lice and PRRS. But even non-SPF breeding herds have a health declaration. As a minimum, all Dan-Bred herds must be declared free of dysentery, mange and lice and have a known PRRS and Salmonella status. All the herds are examined at least once a month by a veterinary surgeon.

The suppliers of DanBred breeding animals are, in part, owners of the breeding and multiplying herds and, in part, industry-approved sellers, including the AI stations, Hatting KS, Mors KS and Vestsjælland KS station.

Production of finishing pigs

The production of finishers usually takes place in one of the following types of production systems:

- Herds producing pigs from birth to delivery for slaughter (integrated production)
- Herds producing and selling weaners (sow herds)
- Herds producing finishing pigs (from bought-in weaners).

Herds with integrated production account for just under half of Danish pig production (45%), where the pig producer improves the genetic properties of the pigs through purchase of breeding stock, purchase of semen from a Danish AI station or a combination of both.

Otherwise pigs are produced in sow herds (9%) or specialised finishing herds (46%). The genetic properties of the sow herds are improved in a similar way, but some pig producers own both sow herds and finishing herds, while weaners usually are traded between sow herds and finishing herds.

“Pig rings”

Around 80% of all trade in weaners takes place through so-called “pig rings” with fixed delivery contracts between a finishing herd and one or more suppliers of weaners. As well as price, the contract usually specifies health status and genetic properties (breed combination). By receiving weaners from one or a few known suppliers of piglets, the pig producer safeguards his herd against introduction of disease.

Producers are allowed to have fixed delivery contracts with a maximum of five herds.

The remaining 20% of weaners are traded in a “pool” system where the recipient receives piglets from several producers. The piglets’ health status is also identified in this system.

In both types of delivery arrangements, the transaction is accompanied by documentation, which ensures that the supplier of piglets is always known to the recipient, and it is not possible to receive pigs of unknown origin.

Multisite systems

Traditionally, the production of piglets and finishers has been carried out in the same complex of buildings. The control of disease has however become increasingly important. Farrow-to-finish herds are now being designed with sectioned compartments so that an entire unit

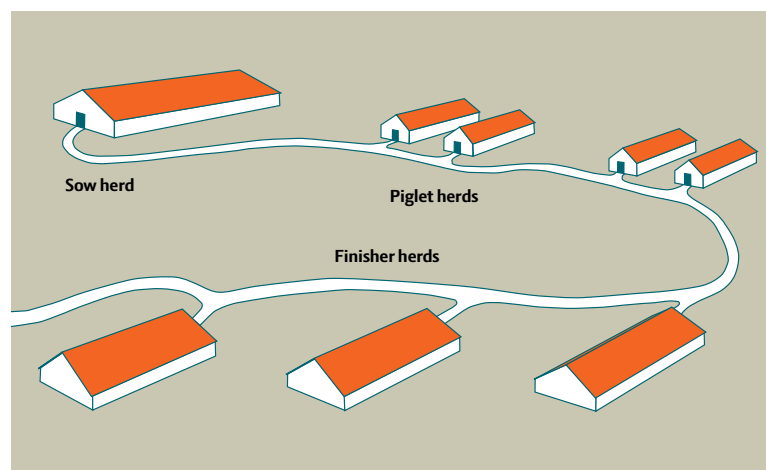


Figure 3: Multisite system

may be filled and emptied at one time. This allows the cleaning and disinfection of the unit before the introduction of a new batch of pigs.

New housing facilities are built with segregated units. The aim is to ensure that sows and finishers are housed at individual production sites, located at a distance to ensure a one-way flow of pigs and avoid movement of personnel between the various units as much as possible. Many producers now run their production of piglets and finishers in entirely separate facilities. Consequently, the risk of disease being transmitted from larger to smaller pigs is eliminated.

1.1.3 Research, development and product testing

Pig producers need access to the best possible research information to assist their management decision making. The Danish industry has made major investments in research and development over many years. In combination with government funded research, this investment has kept Danish pig producers at the leading edge of professional pig production with major importance attached to both the environment and animal welfare.

The pig industry has centralised its research programmes to the benefit of all pig producers and individual research establishments also co-operate closely to make maximum use of the resources available.

The leading research organisations are described below:

The Faculty of Agricultural Sciences, Aarhus University. The faculty's role is to develop understanding of agricultural production systems and ensure its communication to producers.

Technical University of Denmark, DTU, The National Food Institute conducts research, provides education and gives advice on nutrition, food safety, health and environmental matters. The centre is part of the Danish crisis planning group in matters relating to food safety under the Ministry of Food, Agriculture and Fisheries.

DTU Veterinary, The National Veterinary Institute conducts research, provides training and advice on animal disease, both in livestock and domestic animals. Its purpose is to contribute to the production of healthy livestock and animal products through the prevention and control of disease. It is also responsible for crisis planning at veterinary laboratories in Denmark.

The Faculty of Life Sciences, University of Copenhagen, KU Life, is one of Europe's leading academic establishments in the field of food, veterinary medicine and natural resources. KU Life aims to secure the improved well-being of the human population, livestock and plants, through research and education.

The Pig Research Centre is a research body under the Danish Agriculture & Food Council (Landbrug & Fødevarer). The centre is responsible for research and development in the area of primary pig production as well as the dissemination of acquired knowledge. In addition, it is responsible for the management and operation of the Danish breeding system, DanBred. The objective is to improve quality, increase productivity and efficiency within pig production. The main research areas are:

- Nutrition
- Reproduction

- Housing systems
- Production equipment
- Environment
- Health and welfare
- Zoonoses
- Breeding (management of the Danish breeding system).

The Danish Applied Pig Research Programme (DAPR) is the main research activity, which takes place in commercial herds. The tests are development of work carried out by The Faculty of Agricultural Sciences and other research establishments. Around 100 herds are continuously involved in research into nutrition, reproduction and production systems, new equipment as well as animal health issues. This research is conducted in close collaboration with the local Pig Advisory Service (part of the Danish Agricultural Advisory Service) to ensure that the results are immediately available to producers on the ground.

Communication

The work of the Danish Agricultural Advisory Service is coordinated by the main agricultural organisations. This ensures that research results are communicated to producers quickly and effectively. The Pig Research Centre provides information on a weekly basis to specialist pig advisers and other subscribers. Information is also disseminated directly by seminars, meetings and relevant publications and newsletters.

Info Svin

All pig research results are stored on a database (InfoSvin) and a dedicated website (www.infosvin.dk) to enable easy access to relevant information.

1.1.4 Training

Training to be a professional farmer is a vocational education which alternates between formal study and practical training. The training programme begins either with a foundation course at a technical college or practical experience. Training to be a farmer takes 3 years and 8 months. After the initial basic training programme, the student may choose between the following specialised fields:

- Livestock farming
- Arable farming
- Machine operator.

A student may also choose a shorter course and train to be a farm worker. This is a two-year programme (Module 1). The student may subsequently return and complete the training as a professional farmer (Module 2).

Livestock farming

In addition to basic knowledge about livestock, a key component of the programme is the provision of in-depth knowledge about the daily care of animals. Subjects like disease prevention, animal welfare and behaviour, the operation of machinery and technical installations used in livestock farming, are all important elements of the training.

Professional farmers are able to take responsibility for a production area for an extended period and for short-term planning.

As a further stage in the training programme, there are opportunities for management training. This comprises three steps:

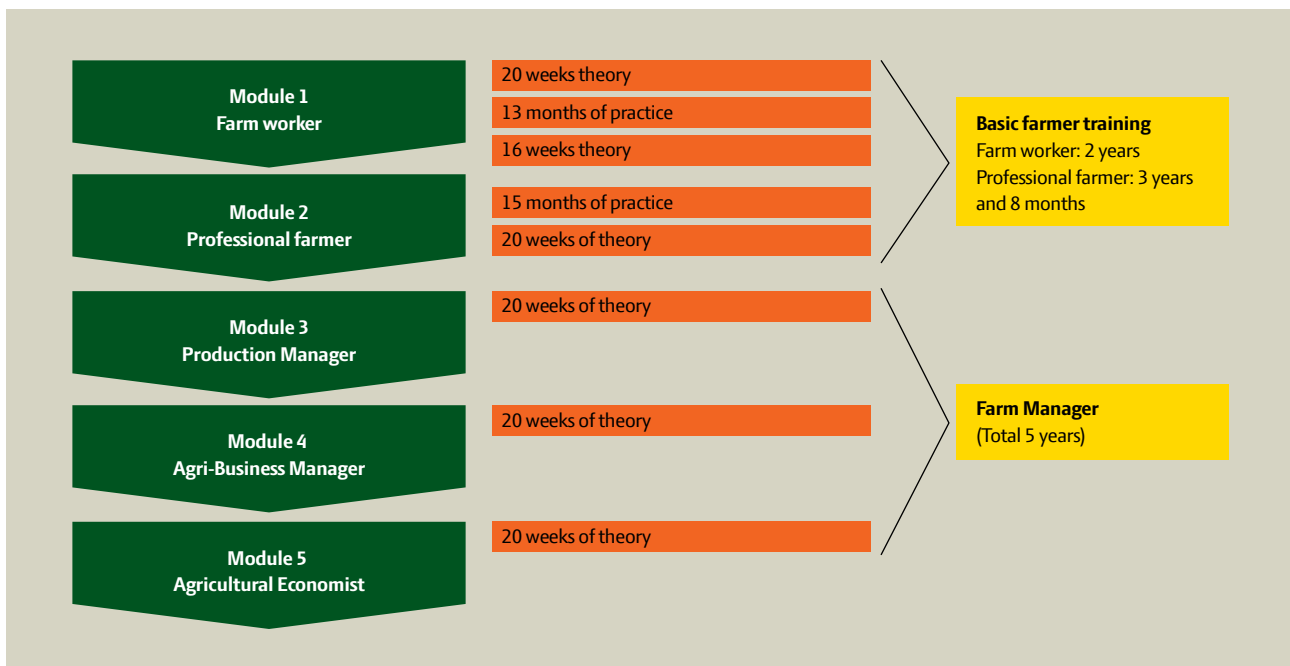


Figure 4: Training of farmers.

- Production Manager
- Managing an Agri-Business
- Agricultural Economist.

Having passed Module 3 (Production Manager), farmers receive a Green Certificate, which entitles them to operate as an independent farmer, acquire an agricultural holding of more than 30 hectares, obtain favourable start-up loans and receive agricultural grants. Individuals without a Green Certificate may only run a farm if they employ a colleague with a Green Certificate.

A Production Manager is entitled to:

- Organise and undertake agricultural production affecting biological, production engineering and financial accountability
- Analyse and evaluate agricultural production and on this basis implement changes in daily production
- Assume responsibility for managing, developing and motivating personnel at a farm and training young people during their agricultural education.

Modules 4 and 5 build on the Production Manager training programme and are designed for individuals who intend to manage a larger operation. The manager is then qualified to produce strategic plans for the development of a substantial agricultural holding.



Farmers in Denmark have access to a comprehensive Advisory Service, with 19 regional offices throughout the country. 70 specialist pig consultants are employed to give independent advice to producers.

1.1.5 Advisory Service

Pig Advisory Centres: Danish pig producers are organised in local farmers' associations, which jointly operate under the Danish Agriculture & Food Council (Landbrug & Fødevarer). Each local association has a special advisory service of ering consultancy service.

Denmark has a well developed advisory system with regard to pig production having 19 advisory centres across the country with 70 pig specialists offering a full consultancy service for producers. The consultants are able to give independent and objective advice as they are employed and managed by local pig production committees, which consist of pig producers and are organised under the auspices of the Danish Agriculture & Food Council (Landbrug & Fødevarer).

Around half of Denmark's pig producers use the service at least four times annually to help with production recording and many others use the service for guidance on new investments, in relation to welfare and environmental matters.

The task of these advisers is to offer pig producers general consultancy on production systems, e.g. housing design, animal welfare and health as well as feeding regimes. In addition, they have a role in training producers and acting in a "trouble-shooting" capacity on technical issues.

1.1.6 Control

Within the Danish breeding system, the industry itself supervises production data, animal health and related matters. In addition, all producers are subject to extensive control by the Danish authorities.

Local authorities must ensure that the rules regarding the size and type of production are observed (see 1.4.2). The Danish Veterinary and Food Administration employs a team of local officers (see 1.5.3), who are responsible for ensuring that producers observe welfare and other relevant legislation. The Danish Veterinary and Food Administration also manage the programme for surveillance of residues in meat (see 5.1.1).

The Danish Plant Directorate, part of the Danish Ministry of Food, Agriculture and Fisheries, is responsible for the control of feedstuffs as well as the approval and control of slurry disposal contracts (see 1.4.5).

1.1.7 Summary

Hectare: One hectare is 10,000 m².

Any person wishing to acquire an agricultural holding of more than 30 hectares in Denmark must have a formal qualification. This education ensures that farmers are fully competent to manage a working farm unit.

These training programmes also ensure that Danish farmers are fully conversant with modern farming methods and techniques.

The Danish Agricultural Advisory Service is a quite unique organisation and ensures that impartial and objective advice is available to all producers.

The producers' membership of co-operative slaughterhouses ensure that any necessary actions can be quickly implemented and problems resolved immediately, which is critical, for example, in the case of disease prevention measures.

1.2 Breeding programme

1.2.1 The Danish pig breeding programme

Home testing: In the breeding herds, all boars and gilts are tested by recording daily gain and lean meat percentage. The conformation of the carcass is also assessed.

The breeding and multiplying herds in the DanBred system must adhere to a special contract determined by the Pig Research Centre. All breeding results have to be recorded in the centralised Pig Breeding Databank.

There are fixed requirements for the size of the herds. It was agreed that from 2007, Landrace and Yorkshire herds must produce at least 300 and Duroc herds at least 200 purebred animals per year. No individual breeder may own more than 10% of a particular breeding population of the Landrace, Yorkshire and Duroc breeds. The largest herds in the breeding programme produce pigs of all three breeds (see 1.2.2)

The reason for stipulating the minimum size of individual herds is that it is not possible to conduct efficient home testing or environmental assessments properly in smaller herds.

The upper limit in size of herd is to ensure that no individual breeder has a dominant position within the overall programme and to avoid any health risks associated with having too many animals on a single farm.

All herds in the DanBred system must have a health declaration and each herd is examined once a month by a veterinarian.

1.2.2 Performance

Heterosis effect: When two pig breeds are crossed, a "heterosis effect" is obtained, meaning that the offspring's performance is better than the average of the parents' performance.

Just three breeds are used in the Danish breeding system. Landrace and Yorkshire are used as female lines and Duroc is used as a male line.

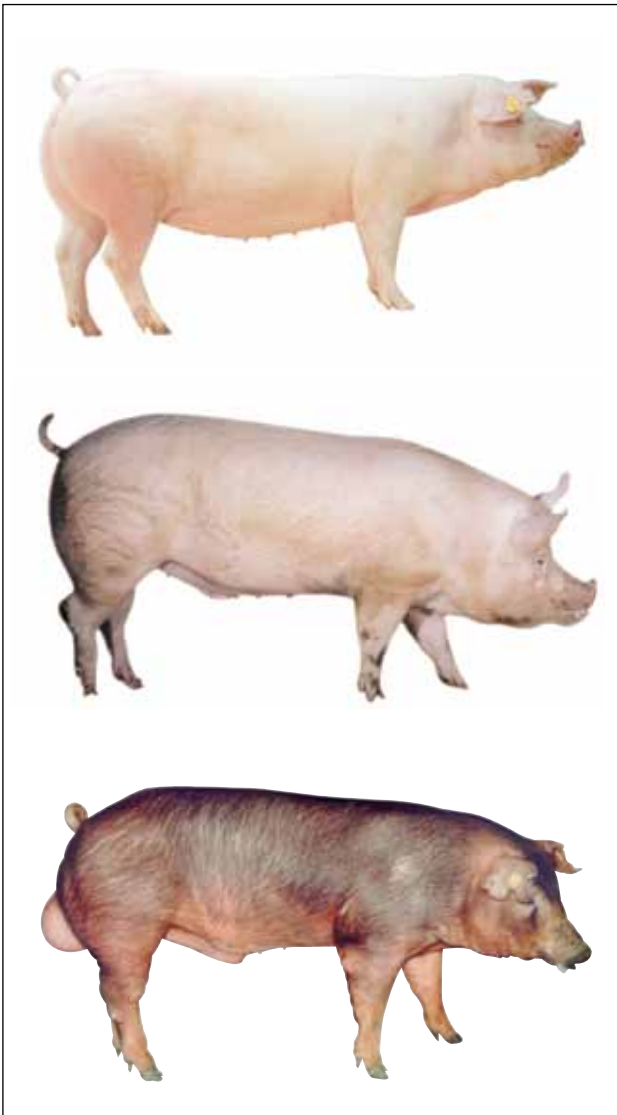
In the programme, the single breeds have the following abbreviations: L = Landrace, Y = Yorkshire, D = Duroc. When using abbreviations for cross-breeds, the boar is always placed first. For example: the abbreviation LY signifies the offspring of a Landrace boar and a Yorkshire sow and L(YL) means the offspring of a Landrace boar and a YL sow.

Landrace (L)

Danish Landrace, one of the female lines in the Danish cross-breeding programme, is known for its good carcass and meat quality and for being a robust pig with strong legs. Owing to its high fertility, the Landrace is used with the Yorkshire for breeding LY and YL gilts, which are the best cross-bred sows for the production of finishers.

Danish Yorkshire (Y)

Yorkshire, the other female line in the Danish breeding system, has a high meat percentage, high daily gain, high feed efficiency and good meat quality. Fertility and mothering characteristics are excellent. Along with the Landrace, the Yorkshire provides the best cross-bred sows for the production of finishers.



The three Danish pig breeds are Landrace, Yorkshire and Duroc.

Danish Duroc (D)

Danish Duroc originates from the USA and Canada from where it was imported in the late 1970s and used for cross-breeding programmes. It is the dominant male line today.

Today, DanBred has the largest breeding population of Duroc pigs in Europe. Danish Duroc produces large litters and rapidly growing finishing pigs with good feed efficiency and lean meat percentage. An additional benefit is the production of carcasses with good meat and eating quality.

1.2.3 Crossbreeds

Nucleus, nucleus herds: Health considerations have led some pig producers to produce their own breeding animals, instead of purchasing them from outside. This takes place in a nucleus herd, where genetic improvement is ensured through the purchase of semen.

By crossing LY/YL female animals with Duroc boars, producers obtain a full “heterosis effect” of improved meat quality and optimum production results.

DanBred D boars	DanBred LY/YL sows
Strong legs and hooves	Good fertility
Good libido	Good underline
High lean meat percentage	Good longevity
Good meat quality	Easy handling

Some Danish farmers producing their own gilts have chosen not to have a nucleus herd consisting of pure-bred Landrace or Yorkshire but to base their breeding programme on alternate crossing with the two breeds. This is also known as “zigzag crossing”.

1.2.4 Breeding objectives

Litter size: LG5-numbers express the extent to which the breeding animals’ genes are expected to influence the number of live pigs per litter (on the fifth day after farrowing). LG5 is only included in the breeding objective for the Landrace and Yorkshire breeds.

Feed conversion: The target is expressed as a reduction in the pig’s feed consumption per kg daily gain. The unit is FUp/kg daily gain with 1 FUp = 7.72 MJ (FUp stands for Feed Unit pig)

The breeding goals are a general expression of all the genetic properties for which improvement is sought. These objectives also take into account economic considerations for both the producer and the slaughterhouse. The overall objective is to produce high quality pork at the lowest possible cost, to ensure the competitiveness of Danish pork on world markets.

The Pig Research Centre determines the breeding goals for the three breeds in the Danish pig breeding programme. This process involves representation from both the breeding side and the slaughterhouses, who both propose traits for inclusion in the overall breeding goals.

The chosen traits must meet a number of requirements:

- Heritability
- Quantification, (either directly or indirectly)
- Significance in terms of productivity
- Economic value capable of validation.

The breeding goals vary between male and female lines. The table below illustrates the economic significance of particular breeding goals.

Economic coefficients of traits within breeding goals		
Daily gain (0-30 kg)	DKK	0.12 per gram/day
Daily gain (30-100 kg)	DKK	0.12 per gram/day
Feed conversion	DKK	132 per FUp/kg gain
Lean meat percentage	DKK	8.6 per % meat
Litter size (day 5):	Sow lines	DKK 26 per pig/litter
Conformation:	Boar lines	DKK 12.5 per score
	Sow lines	DKK 12.5 per score
Killing out, %	DKK	-5 per kg
Longevity	DKK	0.85 per kg

Example: If feed consumption is reduced by 1 FUp/kg gain, a saving of DKK 132 is achieved.

The table below shows the level of improvement, which can be attributed to individual traits. It also shows how litter size is included in the breeding goals for female lines but not for the Duroc boars. In addition, conformation is also included in the breeding objectives.

The more traits included within a breeding goal, the less the improvement per trait that can be achieved. However, the overall economic value of the improvement in the genetic properties in the breeding

objective increases. Other factors than just the number of traits in the breeding objectives influence each trait's contribution to the economic improvement within individual breeds. The heritability of the traits, the genetic relationship between the traits and the number of animals tested (see 1.2.8) are important factors for the determination and size of breeding goals.

	Duroc (boar lines)	Landrace + Yorkshire (sow lines)
Killing out, %	6%	2%
Feed conversion	39%	29%
Conformation	11%	7%
Daily weight gain 0-30 kg	5%	2%
Lean meat percentage	12%	5%
Daily weight gain 30-100 kg	27%	5%
Litter size (Day 5)	-	38%
Longevity	-	14%

1.2.5 Quality traits

PSE: PSE is an abbreviation for Pale Soft Exudative. PSE meat is light, soft and exudative. PSE appears in pork when the animals have a single or double strand of the halothane gene and if they are stressed at the time of slaughter and a particularly rapid pH drop in the muscles occurs. PSE meat is unsuitable for most forms of processing. The halothane gene is no longer found in Danish breeding stock.

pH value: pH is an expression of acidity. The pH scale is logarithmic with a neutral pH=7 linked to water. pH values above 7 indicate that the liquid is basic while pH values below 7 express that the liquid is an acid. pH in pork expresses the acidity of the liquid which constitutes most of the muscles. The pH value falls approx. 24 hours after slaughter as a result of the muscles' transformation of glycogen to lactic acid. pH is of significance to the water holding capacity of the meat.

Breeding objectives are primarily concerned with lean meat percentage and absence of PSE. Previous problems with pH and PSE have been solved by removing the Halothane and RN⁻ gene from the breeds in the DanBred system.

Lean meat percentage

The lean meat percentage in Danish pigs has now reached a level of around 60%, which the industry considers ideal. Consequently, lean meat accounts for a relatively small part of the breeding goal. However, it continues to be a necessary part of the breeding work in order to maintain it at its present level. This is partly due to increasing slaughter weights as well as other breeding objectives, which may have a negative influence of lean meat percentage.

Water holding capacity/PSE

As regards PSE, the objective is to ensure that its frequency does not exceed 2% in the loin and 4% in the gammon. PSE is an undesirable trait in all types of meat and the requirements for PSE frequency in loins and gammons are currently being achieved.

The presence of PSE after slaughter is very closely related to the halothane gene Hal^h. The halothane gene is transmitted as a single recessive gene. Pigs that are homogenous for the gene (nn) will all develop PSE after slaughter while 15-25% of the pigs that are heterogenous for the gene (Nn) will develop PSE.

PSE problems can be solved by removing the halothane gene. This has now been successfully eliminated from the Danish breeding programme.

pH

The pH value of meat primarily plays a role in relation to the production yield of processed meat products. The pH level is about 5.5 in loin and 5.6 in the gammon.

Research indicates that since the RN⁻ and Halothane gene have been removed from the Danish breeds, pH no longer influences production yield.

1.2.6 Production traits

A number of traits in the breeding goals are important for both the productivity and economy of pig production. In particular they affect feed conversion, conformation, daily gain, litter size and longevity.

Feed conversion and daily weight gain

Because feed conversion and daily gain have a significant effect on the economies of production, great importance is attached to these two traits.

Conformation

Good conformation is defined by correct position of the legs and normal build. Poor conformation may have welfare consequences and cause injuries to the pigs as well as an effect on longevity.

Longevity

Since 2006, longevity was included in the breeding goals for the Landrace and Yorkshire female lines. Using results from multiplier herds, a breeding value for longevity up to the second litter was established. This value is more significant for longevity than conformation. The criteria for 'longevity' do not just include leg strength but other factors which may be taken into account when selecting for breeding animals within the herd. For example, disease and reproduction problems and factors such as temperament may affect this selection process, but would be highlighted by any variation in this newly calculated breeding value.

A consequence of introducing longevity as a breeding trait is to reduce the significance of the conformation trait in the Landrace and Yorkshire breeds, but nevertheless it still provides a useful source of information.

Litter size (LG5, Live pigs per sow 5 days after farrowing)

For the Landrace and Yorkshire females, selection for larger litter size has been a dominant consideration in setting breeding goals and has achieved significant results. The genetic level has increased by more than three to four piglets per litter, since 'litter size' was introduced as part of the breeding goal in 1992.

A research project entitled 'Super Sow' led to the previous breeding goal 'FGK' being replaced by 'LG5' from mid-2004. LG5 expresses the number of live piglets per sow, five days after farrowing. LG5 combines the total number of piglets per sow with the piglets' survival rate in the first few critical days.

1.2.7 Selection Index

A Selection Index is an estimate of how good a production result can be obtained for each animal, when all the breeding traits are assessed as a whole. Within each breed, the average index of the nucleus sows is always 100. The higher the index of a breeding animal the higher the value of the animal in terms of productivity. The breeding indexes of all animals are updated weekly.

There is an annual improvement in genetic properties of between eight and fourteen index points for each animal. Every year, a similar point deduction must be made from the index level for each breeding animal, from that fixed on the day of purchase. Thus, for a boar purchased in 2003 with an index of 100, this means that in 2009 it will have an expected index of around 40. This factor encourages producers to renew their breeding stock on a more regular basis.

Apart from the Selection Index, breeding values are also published for each trait. A producer may therefore choose animals and semen with the best sub-index for those properties he/she is aiming to improve in his/her herd.

1.2.8 Performance testing

To obtain information about traits for each animal, extensive recording and performance testing of all breeding pigs is carried out. All litters born of Landrace and Yorkshire sows in breeding and multiplying herds are recorded, making a total of more than 125,000 litters annually. All litters born since 1985 are included in the weekly index

calculation, which enables an accurate assessment of the fertility of the breeding population.

Testing comprises an assessment of conformation and build as well as registering daily gain and meat content. This occurs both in the breeding herds where it is known as home-testing and comprises close to 100,000 animals per year, and at the testing station at Bøgildgård where a further 5,000 boars are tested annually.

Home-testing

With regard to the breeding herds, the pigs are fed ad libitum during the entire growth period. There are fixed requirements for the feed mixes and feeders used. In addition, pigs are housed according to sex. Uniform conditions provide the basis for the comprehensive home-testing which is conducted in the weight range of 30-100 kg.

Every second week the breeding herds are visited by a technician from the Pig Research Centre, to test the performance of the animals. Prior to the visit, parental data is gathered for all pens that are to be tested and ultrasonic scanning is carried out to assess the conformation of the pigs. On this basis, the animals' daily gain, lean meat percentage and conformation are determined. Finally, before leaving the herd, the technician can calculate a provisional index for the tested animals to indicate which animals should be selected for further breeding, sold as breeding animals or sent for slaughter.

For both breeding and multiplying herds, the owner registers the following data for collection in the central breeding database: replacement of sows, litter and service records and weighing in of pigs in the home-testing. Every Wednesday evening, the national index for all breeding animals is calculated and comprises all the records from the breeding herds and test station.

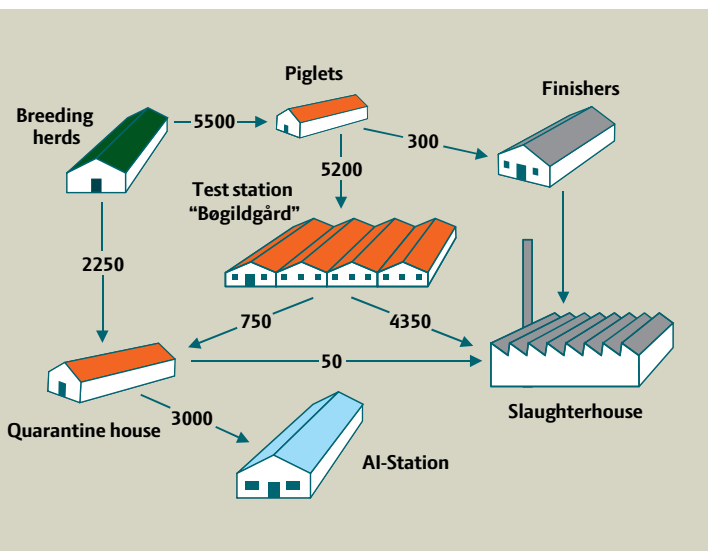


Figure 5: Testing of boars at Bøgildgård.

Test Station (Bøgildgård)

Home-testing for the breeding herds is supplemented by the testing of young boars at a test station. Animals are selected at four weeks from the breeding herds, from the litters with the highest genetic value in the week in question. Testing at the station is conducted to ensure selection of the most suitable boars for Artificial Insemination (AI) purposes. By gathering these animals for testing in a single location, it is possible to obtain a better comparison of individual traits.

The Danish pig industry owns the test station at Bøgildgård, which has capacity for 5,000 animals. The test procedure is shown in Figure 5.

The boars enter a weaning unit, where they stay for 5 weeks so they can achieve similar health status before being transferred to the test units. Testing is carried out on the same basis as home-testing but all

pens are equipped with computerised feeders in order that individual feed intake can be recorded.

After the performance test, the best boars are then selected for AI purposes. All other boars are slaughtered. After slaughter, the meat quality and other properties that cannot be quantified for live animals, for example killing-out percentage, are recorded, to ensure that no unwelcome traits are allowed to develop.

1.2.9 Traceability

All breeding animals are equipped with a unique ID Number.

Earmarking and recording of animals

Within the first 24 hours after birth, all animals in the breeding and multiplying herds are ear notched with an identification number containing a link to the mother's ID. This data and ongoing registration of current data for the breeding and multiplying herds are reported by submitting appendices – often electronically – to the breeding office and collected in the central breeding database.

Replacement of breeding animals

Replacement of breeding animals in both breeding and multiplying herds is recorded by the herd owner, who reports the entry and slaughter of breeding animals in the previous month to the Pig Research Centre. This information is entered into the central breeding database and is checked for errors and omissions. Data on replacement of breeding animals serves as a basis for controlling the origin in later reports. In addition, summary reports are prepared and used for the control of breeding animals present in the herd.

Service lists and farrowing records

All servicing in breeding and multiplying herds is reported to the breeding office on a monthly basis.

Farrowing records for Landrace and Yorkshire animals must be submitted twice. Within 16 days of farrowing, the record must be submitted with information on origin, date of service, farrowing date, number of piglets born and live pigs five days after farrowing. After weaning, the farrowing record must be resubmitted with information on ID numbers of the pigs from the litter.

1.2.10 Control of the breeding system

The breeding office checks the data submitted for errors and omissions by cross-checking with the central breeding database. Checks are made, for example, as to whether the names and ID Numbers of the parents correspond. The farrowing date is compared with the date of service.

The breeding value for litter size (LG5) is calculated on the basis of litter data.

The breeding pedigree has a significant influence on genetic improvement as performance information about related animals from several generations is included in the calculation of breeding values. Since the resulting breeding index forms the basis for the selection, it is important that all parent data is correct. Routine checks are performed on parents in all breeding herds. As in the multiplier herd, spot checks are carried out on parent stock.

In addition, a regular assessment is made of how well the improved genetic properties are transferring to commercial production.

1.2.11 Summary

All breeding animals in DanBred are free of the halothane gene. It is of vital importance to the quality of Danish pork that the halothane gene – and thus PSE occurrence – is not present.

As regards lean meat percentage and litter size, improvement has been significant. Daily gain and feed conversion are influenced by breed and production environment. This means that, on average, production herds are only capable of achieving about 80-90% of the genetic improvement, which can be realised in breeding herds.

Genetic improvement can be stated in production data or expressed in financial terms. From an economic point of view, this improvement represents an increase in the contribution margin of DKK 10.00 per annum for an (D) (LY) finisher.

Breeding stock from DanBred is frequently compared with females from other breeding companies and with conclusive results. The DanBred breeding programme has not only achieved an improvement in genetic properties, but has succeeded in improving meat quality as well as realising an improved return for producers.

1.3 Welfare

1.3.1 Legislation and industry agreements

The Animal Welfare Act (1991) in Denmark requires that all farm animals, including pigs, must be properly housed and tended. The rules provide an overall framework, but do not lay down specific details for housing of specific categories of animals.

The Animal Welfare Act is the responsibility of the Ministry of Justice. Two specialist committees advise the Ministry of Justice on animal welfare issues: the Ethical Council for Animals and the Committee for Animal Welfare. The committees recommend amendments to the Minister of Justice.

A regulation on protection of pigs, which implements EU regulations (91/630/EEC), lays down more specific requirements. The general provisions have been in force since September 1991 while the rules specified by the EU Directive took effect on 1st January 1994.

For any new sow housing units which came into operation after 1st January 1999, separate rules (Act No. 404/1998) laid down specific provisions.

For any new piglet and finishing units, which came into operation after 1st July 2000, separate rules (Act No.104/2000) laid down specific provisions for housing piglets, breeding and finishing pigs.

Housing units are also subject to specific regulations, (Act No. 295/2003) with specific provisions for keeping pregnant sows, piglets, breeding and finishing pigs in indoor units.

Following publication of two EU Directives in 2001, Danish legislation concerning housing of pigs has been subject to further revision. The new regulations, which came into force on 15th May 2003, lay down provisions for:

- New area requirements for loose sows during pregnancy
- New flooring requirements for loose sows and gilts during pregnancy
- Access to straw or other high-fibre feed or material for all sows and gilts
- Continuous access to manipulable materials for all piglets and finishers.

From 1st January 2005, new rules (Regulation 1120/2004, with changes to Regulation 323/2003, on Protection of Animals) required that all pig housing must have provision for special hospital pens for sick or injured animals.

Further rules (Act No.173/2001) laid down specific provisions for keeping pigs outdoors.

Separate regulations regarding tail docking, teeth grinding and the castration of male piglets were established recently (Regulation No. 323/2003). This regulation contains more stringent requirements as to the timing of these operations and the competency of the persons carrying them out. The requirements are in line with EU provisions.

Since 1975, the Danish pig industry has run a programme for testing and evaluating pig housing systems and equipment. The purpose is to prevent the marketing of systems and products, which are detrimental to the animals' well-being or overall production economy.

The Pig Research Centre have developed a set of detailed guidelines for the design and management of pig housing, which take into account both the requirements of legislation and results from this practical research and development work.

1.3.2 Pig housing

Pig housing must be designed to meet the demands of rearing livestock with due regard to animal health and welfare. Any equipment used should not harm the animals in any way and should be easy to clean and maintain.

The Animal Welfare Act specifies that the design of areas for housing of animals must accommodate the needs of animals, and ensure they have the necessary freedom of movement during intake of feed and water and when resting. In addition, animals must be protected against wind and weather according to need.

For new housing units which came into operation after 1st July 2000, a showering system must be installed in the pens for pigs over 20 kg.

The legislation will apply to all housing units from 1st July 2015. In gestation units for loose sows built after 1st January 1999, these showering systems must also be installed to help the animals regulate their body temperature in warm weather. This will apply to all housing units from 1st January 2014.

From 1st January 2005 a requirement has been in place for all units to have adequate number of sick pens, and there should always be a free area available for immediate use. Additional space and lay-out requirements also apply.

Space requirements

Pig housing must be designed in such a way to ensure that every animal may get up and lie down and rest without difficulty. They must



For new housing units which came into operation after July 2000, a showering system must be installed for all categories of pigs over 20 kg, including pregnant sows. This helps the animals regulate their body temperature during warm weather.

also have access to a clean lying area and be able to see other pigs. There are also space requirements relating to the weight of the pigs.

Space requirements for various weight categories of pigs	
Weight interval, kg	Space requirement, m ²
<10	0.15
10-20	0.20
20-30	0.30
30-50	0.40
50-85	0.55
85-110	0.65
>110	1.00



From January 2005, legislation in Denmark has required that all pig units must have sufficient number of special pens, where any sick or injured pigs may be moved immediately to obtain special treatment and care.

For housing which came into operation after 1st July 2000, the following also applies:

- In pens for pigs under 10 weeks age, half the minimum area required by law must be a solid or drained floor, or a combination of both (Regulation No. 104/2000)
- In pens for pigs of more than 10 weeks age, one third of the minimum area required by law must be a solid or drained floor, or a combination of both (Regulation No. 104/2000).

The legislation will apply to all housing units from 1st July 2015.

Equipment and materials

Any materials or equipment used must not be capable of injuring the pigs and must be able to be cleaned and disinfected with ease.

The Danish Applied Pig Research Programme therefore tests all new equipment in order to draw up guidelines for its use.

Flooring

Flooring must be neither slippery nor uneven, thus reducing the risk of the pigs being injured. It must be designed to ensure the comfort and safety of the animals, and the material used must provide an even and stable surface appropriate to the weight of the pigs. The lying area must be comfortable, clean and adequately drained and if bedding is used, it must be clean and dry and safe for the animals.

Slatted floors are still widely used for both health and for practical reasons. Around half of all finishing pigs are still produced on fully slatted floors of concrete, while farrowing pens and pens for weaners are usually based on partly slatted floors. Fully slatted flooring will be phased out by 1st July 2015.

Water supply

Pigs of more than 2 weeks age must have access to fresh water in sufficient amounts.

Equipment for feeding and watering must be designed, manufactured, located and maintained to ensure no possible risk of contamination of feed and water supplies. In most systems, water is available ad libitum, and the animal can drink to meet its specific needs.

Ventilation

Room temperature, air circulation and dust may affect the well being of the pigs. Therefore, the air exchange rate must be adjusted so that the ventilation system removes excess heat, moisture and dust particles.

An emergency ventilation and alarm system must be installed in all housing with mechanical ventilation. The alarm system must be equipped with a local siren or be connected to a control centre. The Danish pig industry has a dedicated team to advise producers on indoor production environment. Technicians have been specially trained to analyse the environment and pig producers can use this service to identify any shortcomings in their production systems.

Lighting

Pigs must not be kept in darkness for indefinite periods. There must be natural or artificial lighting equivalent to 40 watts, for a minimum period of 8 hours. Most pig housing is equipped with both artificial lighting and natural light through windows.

Straw

Loose housed pregnant sows must have access to straw or other high fibre feed or material. Straw is used in 'two-climate' units for piglets and finishing pens, when the animals are transferred to them initially.

In partnership with Aarhus University, the Danish pig industry has embarked on a comprehensive research project aimed at determining the optimum amount of straw for pigs. The amount of straw must satisfy the pig's natural rooting instincts while taking account of hygiene and environment in the current housing units.

Manipulable Materials

From 15th May 2003, all weaners and finishers must have had permanent access to straw or other manipulable materials. This only applies to new housing for sows and gilts until 1st January 2013, when it will apply to all housing units. Materials that can be used are typically straw, hay, wood chippings and compost, which do not pose any animal health problems. Rope made from natural materials may also be used.



Temperature, air circulation and absence of dust are important factors contributing to the well-being of the pigs. Therefore, the air exchange rate must be maintained to enable the ventilation system to remove excess heat, moisture and dust particles.



For all sow units which came into operation after January 1999, a system for group housing of pregnant sows must be used (apart from the first four weeks after service). Today, these group systems are used for around 75% of the Danish sow herd.

Cleaning

For hygienic reasons, particularly relating to control of Salmonella, weaning and finishing units are built with partly closed pen walls, to avoid direct contact between the different categories of pigs. This system makes it possible to clean and disinfect the individual unit regularly.

'All in - all out' (AI-AO) production systems have been widely adopted in Denmark. The purpose of AI-AO management is to ensure that any disease outbreak in one group of animals is not transmitted to the next group within a housing unit. A thorough process of cleaning and disinfection is carried out prior to the arrival of new animals. A range of special materials has been developed for this purpose.

1.3.3 Housing of sows and gilts

All sow units which came into operation after 1st January 1999 have had to be designed for loose housing of pregnant sows, from no later than four weeks after service. Traditional sow stalls in operation before 1st January 1999 may continue in use until 1st January 2013. All tethering of sows was banned from 1st January 2006.

For new sow units which came into operation after 1st January 1999, there are additional requirements:

- Showering systems must be available to allow sows to regulate their body temperature

- Pregnant sows and gilts must have access to straw or similar substances, which meet their rooting needs
- At least 1.3 m² per sow and 0.95 m² per gilt of the floor space must be solid or drained or a combination of both and have straw or similar materials available. The space requirements depend on the group size and the proportion of gilts.

In the new sow units, the sows and gilts must be loose housed in groups until seven days before expected farrowing. In the last week leading up to farrowing, the sows and gilts must be provided with suitable nesting material, unless the technical requirements of the slurry system installed make this impracticable.

1.3.4 Management

The Animal Welfare Act provides that:

- Animals must be treated properly and safeguarded in the best possible way against pain, disease, fear, permanent injury and discomfort
- The person managing the animals is responsible for their care and considerate treatment, including adequate provision of feed and water, and must have due regard for their physiological and behavioural needs.

This means that all pigs in Denmark must be fed and inspected at least daily. Sick and injured pigs must receive immediate attention and should be moved to a special hospital pen. There must be an adequate number of hospital pens and always at least one ready for use. If a pig remains sick for a prolonged period, the animal should be put down or a veterinarian consulted.

In Denmark, pigs are usually weaned at 28 days at the earliest, but may be weaned at 21 days, if they are moved into special housing

units that are cleaned and disinfected before arrival of each batch. These units must be separated from sow units in order to minimise risk of disease spread.

Tail docking/Teeth Grinding/Castration

Tail docking and grinding of teeth are not allowed on a routine basis. These practices may only be carried out if there is clear evidence



Close co-operation between the authorities and the industry, together with a good information network, ensures that all new legislation is swiftly implemented at farm level.

of injury to the sows or other pigs. Tooth grinding must take place within the first four days of birth. In practice, if carried out, it normally takes place within the first 24 hours of birth out of consideration for the sow's welfare. It must be carried out by a vet or specially trained personnel. Tooth clipping is not permitted.

Tail docking must take place within four days of birth and only if it can be formally documented that the occurrence of tail-biting cannot be avoided by other means. Only a veterinarian or specially trained personnel may carry out tail docking, and no more than half the tail may be docked. If the operation occurs at a later date, the piglet must be anaesthetised.

If castration of piglets is carried out, it must be conducted as soon as possible and within seven days of birth. After this time only veterinarians or specially trained personnel may carry out the operation and anaesthetic must be used.

From 1st June 2009, it became a requirement that pain relief is administered to piglets before castration. Pain relief results in improved animal welfare, largely because post-castration pain is reduced. The requirement is an integral part of the Danish Product Standard (see 1.1).

1.3.5 Development of production and housing systems

Development of new housing systems is carried out both by government agencies and by the industry itself. Development work is properly co-ordinated between various institutes and organisations, which mean that several groups of researchers may be involved in the same projects. This approach ensures that all possible factors are taken into account and that results can be quickly communicated and implemented on the ground. Research and development focuses

on key issues identified by the Ethical Council for Animals but is also influenced by public debate and market demands.

Since the late 1980s, the welfare and health of animals have been the focus of major research activity. The main objective has been to improve the levels of welfare and health in existing systems as well as development of new systems.

The main areas for current research and development activity are:

- Loose housing systems for pregnant sows
- Loose housing systems for lactating sows
- Design of pens for weaners and finishing pigs
- Rooting material for weaners and finishers
- Prevention of tail biting
- Use of hospital pens
- External environment.

The research programme is carried out in collaboration with research establishments such as the Faculty of Agricultural Sciences (see 1.1.3) as well as field trials conducted by the industry itself.

1.3.6 Control

Since the autumn of 1994, local veterinary officers, employed by the Danish Veterinary and Food Administration (under the Ministry of Food, Agriculture and Fisheries) have been charged with ensuring that provisions laid down in the Animal Welfare Act are being observed. Local veterinary officers are allowed free access to production units and animal transport and may demand to see all required documentation. EU Commission officials are also allowed similar access.

At least 5% of Danish producers receive formal visits by the authorities each year or in cases where mistreatment of animals is suspected.

Welfare is also checked as part of the industry's Danish Product Standard (see 1.1) with independent audits carried out in a third of all herds every year.

In addition, all local vets are obliged to report any cases of welfare abuse to the local office of the Danish Veterinary and Food Administration. All employees of the Danish Agriculture & Food Council (Landbrug & Fødevarer) are also obliged to report similar cases found during their routine farm visits. A hotline has been set up for everyone else in contact with pig herds. This is operated by employees of the Pig Research Centre under the auspices of The Danish Agriculture & Food Council (Landbrug & Fødevarer). Its purpose is to prevent a problematical situation developing into one of neglect.

All pigs arriving at the slaughterhouse are also subject to a formal veterinary inspection during unloading and, again, any evidence of abuse must be reported to the appropriate authority.

1.3.7 Summary

The welfare of Danish pigs is assured by good practice, supported by a range of official controls. Close co-operation between the various authorities and the industry itself, supported by a first class advisory service, ensure that producers are equipped with the latest technical information and are fully conversant with all the rules and regulations affecting welfare and health of animals.

Extensive research and development also provides the basis for a sound legislative framework. Around 75% of Danish sows are now loose housed during their pregnancy.

Co-operation between the authorities and industry organisations ensures that all aspects of health and welfare are properly considered in all research and development work. It is crucial that animal

behaviour is subject to proper independent scientific evaluation in order that optimum solutions can be developed for new housing and production systems.

Recent Danish legislation concerning the welfare and health of all categories of pigs is among the strictest in the whole of the EU.

1.4 Environment

1.4.1 Legislation and industry agreements

In addition to the requirements for animal health and welfare, Danish legislation also lays down a series of requirements to address the potential environmental impact of pig production, covering such areas as:

- Location and design of livestock production units
- Size of livestock units
- Arable land requirements for livestock producers
- Slurry disposal requirements.

The Ministry of Environment and Energy has established rules for storage, transport and application of animal slurry in Denmark in order to comply with EU regulations (91/676/EEC). The legislation is aimed at minimising pollution and the environmental impact of livestock units.

From January 2007, a new regulation for environmental approvals of livestock enterprises came into effect. The new rules are contained in a new law (Act No 1572/2006), supported by other detailed requirements (Regulation No 1696/2006), as well as specific rules for holdings larger than three Animal Units, regarding waste disposal and silage production (Regulation No 1695/2006).

The Danish Agricultural Advisory Service has developed a series of guidelines for their local pig advisers whose task it is to assist producers in the planning and management of the livestock production.

1.4.2 Location and design of agricultural holdings

AU, Animal Unit: A standard for the number of animals kept on a farm. A single Animal Unit is based on a quantity of 100 kg nitrogen ab lager (stored slurry) and corresponds to:

- 4.3 sows per year with suckling pigs (4 weeks to 7.2 kg)
- 175 piglets from weaning (7.2 kg to 30 kg)
- 35 finishing pigs (30kg to 102 kg)

Location

The new regulations require that no livestock units over three Animal Units (AUs) in size may be established or existing livestock units be extended or modified in the following areas:

- Existing or planned urban zone or tourist areas
- Areas used for industrial, recreational or other uses
- A distance less than 50m from the above
- A distance less than 50m from any neighbouring homes.

Additionally, any pig enterprise larger than 75 AUs, being refurbished or extended, must obtain environmental approval based on the new regulations applying from January 2007. In addition to the more rigorous distance requirements (see above), there is a general requirement for a reduction in ammonia evaporation from housing units or slurry storage. For 2009, the reduction requirement is 25% in relation to the unit and storage system with the lowest ammonia evaporation. In practice, this means that any production system using 'fully slatted flooring' will be looking to achieve a reduction of up to 60%.

A number of development projects and trials have been carried out, which have demonstrated how ammonia evaporation and odour



The Ministry of Environment and Energy has drawn up detailed rules for the operation of pig production units, including the storage, handling and spreading of animal slurry. The aim is to minimise pollution and the environmental impact of livestock units. The maximum annual limit for application of nitrogen in animal slurry is 140kg per hectare.

nuisance can be reduced by employing different strategies, such as the adjustment of feeding regimes, choice of particular housing systems and chemical and biological air cleaning systems. These recommendations are described in detail on the Pig Research Centre website (www.infosvin.dk).

The location of livestock units must meet a series of other requirements, as shown in Figure 6.

Land Area 'Harmony Requirement'

All pig farmers must own a certain amount of land for application of animal slurry linked to the size of the production. Any residual land required may be leased from a neighbouring farmer but must be subject to a formal agreement. The 'Harmony Requirement' prescribes

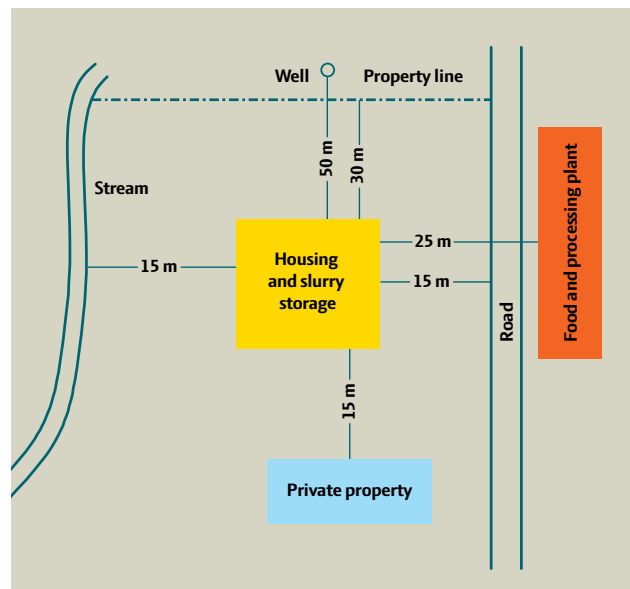


Figure 6: Location requirements for pig housing, slurry tanks, etc.

that the Land Area must be large enough for slurry application equivalent to 1.4 AUs per hectare. With regard to this area requirement, the producer must own 25% of this area when his pig enterprise is less than 120 AUs. For an enterprise larger than 120 AUs, he must own at least 30% of this area.

Land area requirements for pig production	
Animal Units (AUs)	Land Area Requirement (owned by the producer)
<120	25%
>120	30%

At least 65% of the area must be laid out as 'green' fields, such as grass or winter crops.

Design

Livestock systems must be designed to avoid any contamination of the land or ground water. This means that flooring and drainage systems must be fit for purpose.

1.4.3 Slurry storage and spreading

The storage and application of slurry is subject to significant restrictions to regulate its nitrogen impact.

The maximum amount of slurry allowed for spreading corresponds to 1.4 AU per hectare (140 kg N per hectare). Pig units with larger slurry amounts must conclude a formal agreement with other farmers for the transfer or use of the surplus.

Storage capacity must correspond to at least 9 months production, to ensure that spreading only takes place at specific times. Storage units must be covered with a lid or an equivalent cover, to prevent excessive ammonia and odour emissions.

Slurry spreading may only take place while crops are growing, from 1st February till harvest, from harvest till 1st October for maize and from harvest to 15th October for grass.

Every unit producing livestock must prepare formal plans and accounts every year, which include the following details:

- Plan for the crop rotation and areas with 'green' fields
- Plan for application of fertilisers, including slurry and requirement of nitrogen and phosphorus

- Fertiliser and slurry account for the period 1st August till 31st July to be made available to the local authorities.

The fertiliser and slurry account includes requirements for application of nitrogen. At least 75% of the nitrogen in slurry must be utilised. The annual fertiliser plan must be submitted to the Danish Plant Directorate for approval.

1.4.4 Production systems

The majority of Danish pigs are housed in insulated buildings with mechanical ventilation and heating systems. For some pregnant sows in loose housing systems, however, non-insulated units with straw bedding have been established. About 5% of sows are kept in outdoor units in Denmark. Batch production is widely used in accordance with the "all in – all out" principle and most piglets are weaned at an age of around four weeks.

Sows

Pregnant sows are housed either in individual stalls or in a variety of group systems. In housing units built after 1st January 1999, pregnant sows must be kept in groups after the 4 week post-service period. Farrowing sows are housed individually in specially designed pens with partly or fully drained flooring.

Weaners

Weaners are housed in special units, in groups of 20-40 animals, where the temperature and air supply are adjusted to the needs of each age group. Most units are designed with 'two-climate' pens with partly slatted flooring and a cover. The pigs are fed ad libitum and the units are managed on an 'all in – all out' basis. Pigs are kept in the weaning unit from 7 to 30 kg. An increasing number of pigs are now housed in 'wean-to-finish' units (FRATS).



Sows go into a farrowing pen seven days before the litter is due. These individual pens are specially designed to minimise any possible harm to the piglets.

Finishers

Finishers are housed in pens with 12 to 18 animals and are fed ad libitum throughout the growth period. Most systems are equipped with mechanical ventilation, which is automatically controlled. Most pigs are housed in pens with fully slatted flooring, but from 1st July 2015, a third of the flooring must be solid or drained. This requirement has applied to new units built after 1st July 2000. Batch production with 'all in - all out' management is mainly used for reasons of improved

health and hygiene. The pigs enter the unit at a weight of 25 to 30 kg and are sent for slaughter when they reach a weight of around 100 to 110 kg.

In co-operation with the local advisory service, the majority of pig producers undertake regular control with production in individual pens. This enhances the potential for optimal production of sows, piglets and finishers. Data on reproduction, feed consumption and daily gain is included in the registration.

1.4.5 Control and monitoring

It is the responsibility of the local authorities to ensure that the rules for the establishment of livestock farming, storage and spreading of slurry are properly observed. This is achieved by regular control of all farms.

New equipment is frequently tested to ensure that it functions properly and meets the animals' needs. A special agreement between the authorities and supply industry ensures that all flooring systems on the market are durable and fit for purpose. Close co-operation with manufacturers of housing equipment and ventilation systems ensures that research and test results as well as practical pig production experience are incorporated into the development of new products.

The Danish Plant Directorate ensures that compliance with all rules affecting slurry spreading are observed. This is achieved through approval of annual plans as well as inspection of selected farms. Any infringement found is subject to financial penalty.

1.4.6 Summary

Rules for the establishment of livestock farming, storage and spreading of slurry ensure that the industry works in parallel with the production cycle of arable crops rather than causing environmental damage.



The weaned piglets move to new accommodation, usually in groups of 20 to 40 animals. The typical design is a 'two climate' pen, with a partly slatted floor and a covered area.

Legislation also ensures a high level of sustainability in modern livestock farming systems.

Official control, supported by industry agreements, ensure that rules are properly observed and high quality housing and systems are used which pay due regard to the welfare and health of the animals.

1.5 Health

In the autumn of 2008, a new veterinary agreement was concluded with the authorities, which will result in changes to the legislation within the next couple of years. This agreement applies in particular to the following areas:

- Monitoring of Salmonella
- Health consultancy agreements
- Self auditing of animal welfare.

The current regulations are described below.

1.5.1 Legislation and industry agreements

Danish legislation (see 1.3.1) lays down a number of requirements for housing design, which pay due regard to the welfare and safety of the animals (Regulation no. 323/2003).

In addition to this, the industry has drawn up a set of guidelines to ensure a high health level in all pig herds. For SPF herds, even stricter precautionary measures are taken. Producers must have a formal health advisory agreement.

Local veterinarians have a key role in the maintenance of high health levels. The Veterinarian Act outlines the responsibilities of local veterinarians. This act forms the basis of detailed regulations for the use of veterinary medicines (Regulation No. 482/2007) and the establishment of health advisory agreements for pig herds (Regulation No. 927/2003). A summary of the relevant regulations is contained in Appendix 1.

To minimise the presence of Salmonella, the authorities have established a regulation laying down requirements for surveillance of Salmonella in pigs (Regulation No. 112/ 2005). A third Salmonella Surveillance Control Programme was approved by the Danish Veterinary and Food Administration for monitoring of Salmonella in the whole

production chain and became effective in 2002. The fourth plan for controlling Salmonella in pigs is expected to be launched in the latter half of 2009. The plan will define the targets for the next five years.

1.5.2 Health levels for pig herds: conventional and SPF

The Danish industry operates two health levels: conventional and SPF. In conventional or ordinary herds, the animals' health status is not systematically controlled, but is known by the herd owner himself and his veterinarian.

The special SPF status ensures that these herds are declared free from a number of diseases, including mycoplasma, pleuropneumonia, swine dysentery, mange, lice and atrophic rhinitis. SPF herds can only be established by total depopulation, when the previous herd has been slaughtered and the whole unit is cleaned, disinfected and left empty for a specific period, until the introduction of SPF animals. The security of the system is based on a high level of biosecurity and close veterinary supervision.

SPF herds may carry one of the above diseases, but, in this event, the herd may remain a SPF herd but with a qualification, e.g. SPF + ms (SPF with mycoplasma).

Currently, around two-thirds of all sows and a third of finishers in Denmark have SPF status. Many other herds operate to similar rules and standards, although they do not have the formal SPF accreditation.

On the SPF website (www.spfsus.dk), more detailed information on the SPF system can be found, together with information on the health status of all pig herds in Denmark.

1.5.3 Regional Veterinary Officers and Veterinarians

Control Officers and Contingency Managers

The Danish Veterinary and Food Administration is now organised into three administrative areas (North, South and East). Each region has its own Control Officer who has overall responsibility for ensuring compliance with the Animal Welfare Act, while Contingency Managers are responsible for the monitoring and control of infectious animal diseases.

Veterinarians

To practice as a veterinarian in Denmark requires formal authorisation. Only practising veterinarians, who are registered under the Ministry of Food, Agriculture and Fisheries, may treat sick animals. Practising veterinarians are also responsible for reporting evidence of certain diseases to the regional control as well as providing support for any disease control programmes, where necessary.

Veterinarians must purchase prescription medicines at a pharmacy. When purchasing or prescribing medicines, veterinarians must submit their authorisation number. The requirement governing prescription medicines ensures that there is clear separation between the prescription and sale of veterinary medicines, e.g. antibiotics.

The local veterinarian must take action where he finds any abuse of animals taking place and any serious offences must be reported to the police.

1.5.4 Health and treatment

A veterinarian may only hand over or prescribe prescription medicines for the treatment of sick animals on the basis of a formal diagnosis. Prophylactic use of medicine is not allowed. However, if a diagnosis



All use of veterinary medicines must be registered, including details of the animals treated, the type of medicine and the amounts and is subject to the control of the local veterinarian.

is made for a particular animal, then other animals in the pen may receive similar treatment prior to symptoms appearing.

Certain medicines may only be used if the treatment is carried out by the veterinarian. If a particular treatment has a specified withdrawal period (i.e. release for slaughtering), the veterinarian must advise the farmer accordingly and confirm the details in writing.

After completing diagnosis and starting treatment, a veterinarian may only hand over or prescribe further medication for a period of 5 days.

When a veterinarian hands over medicine to the producer, he must advise the producer and confirm in writing the following information:

- Formal diagnosis
- Animals to be treated



More than 90% of the Danish pig producers have a formal agreement with their local veterinarian, including a detailed health plan for the unit. This agreement requires that the local vet visits the producer monthly and prepares a written report on the health status of the herd.

- Dosage
- Means of administration
- Withdrawal period, before animals can be sent for slaughter.

The written record must be kept on-site for five years and the veterinarian must retain it for a five year period.

Unused medicines must not be stored on-site after the prescription period has expired, unless they are re-prescribed during a subsequent visit by the veterinarian.

When a producer uses medicines or non-prescription drugs for farm animals, he must formally record the following information:

- Animals which have been treated
- Date of start and end of medication
- Medicines used
- Reason for treatment
- Dosage and manner of administration
- Person responsible for treatment
- Name and address of the supplier (of non-prescription drugs).

This record must be kept on-site for a period of five years.

Health Advisory Agreement

A producer may enter into a written Health Advisory Agreement with his veterinarian. A copy of the agreement must be forwarded to the regional control in compliance with regulation 927/2003. Around 90% of Danish pig production is now covered by Health Advisory Agreements. The agreement is compulsory for SPF farms.

The Health Advisory Agreement must comprise at least 12 annual visits. The veterinarian must conclude every visit with a formal written report on the health condition of the herd and a plan of action, specifying measures to be taken to improve the health level. These reports must be signed by the veterinarian and counter-signed by the producer. The producer must keep the reports for five years.

A status report must be produced once a year, including a description of the initiatives that have been successful and any new measures to be introduced in future, e.g. planned conversions or extensions.

The veterinarian keeps a record of contact with each herd. The record should contain the following information:

- Data on medicines prescribed (product name, amount, and disease treated)
- Data on the withdrawal period advised to the farmer
- Stock of unused medicines, as well as the number of animals treated
- Pig producer's written certification that the information stated is correct
- Copy of the visit report
- Copy of the farmer's record of medicine use, disease outbreaks and mortality levels in the herd.

The producer must keep a copy of this report for a period of five years.

For herds with a Health Advisory Agreement, the veterinarian may prescribe antibiotics for a maximum of 35 days treatment provided that he has given a formal diagnosis and it is established that the disease could spread to other animals in the herd within the 35 day period. The veterinarian must instruct the farmer on how to use the medicines prescribed. These medicines should not be present on the farm after the 35 days have expired, unless the veterinarian has re-prescribed the drugs during a subsequent visit.

1.5.5 VETSTAT

In Denmark, over 85% of veterinary medicines are sold through pharmacies, while the remainder is used by feed mills or by the veterinarians directly.

All use of medicines for livestock must be recorded in the VETSTAT database (Veterinary Medicine Statistic). The programme registers the use of all therapeutic medicine, sera and vaccines for each herd. The pharmacy, veterinarian and feed mills must submit the following information to VETSTAT:

- Animal type and age group treated
- Identity of the herd
- Diagnosis (or reason for medicine prescription)
- Name and amount of medicine prescribed
- Name of the veterinarian prescribing the medicine.

The information is used by the Zoonosis Centre (under the control of the DTU Food, see 1.1.3) to analyse in detail how medicine is used. The data recorded in VETSTAT provides the basis for examining medicine consumption according to animal species, age, diagnosis and other parameters. It is hoped that this data will allow the authorities

to examine more clearly any relationship between the use of medicines and the occurrence of resistant bacteria.

It will also become possible for farmers and veterinarians to benchmark their own medicine use against other norms measured in the VETSTAT database.

1.5.6 Zoonoses

Zoonoses: Diseases which can be transmitted from animals to humans. For example, a Salmonella infection is a zoonosis.

SI value: As a result of the national Salmonella screening in breeding and multiplying herds, the SI value (Salmonella Index) is calculated on the basis of the results from the past three months sampling.

The Salmonella level in all breeding and multiplying herds is closely tracked by means of serological testing. This programme began in late 1993 as a voluntary agreement between the industry and the Danish authorities. From these investigations, a Salmonella Index (SI) is continuously updated for each herd. If the SI value exceeds a fixed limit (SI value >5), further tests must be carried out in the herd and buyers of breeding pigs must be informed.

When selling pigs from breeding and multiplying herds, the SI value must be included in the herd's health declaration.

Since January 1995, the Salmonella level in all production herds delivering more than 200 pigs per year has been monitored regularly by serological testing of meat juice samples taken from pigs delivered to the abattoir. The results of these tests are published monthly and

are available to the slaughterhouses, the Danish Agriculture & Food Council's Veterinary Department and the public authorities.

The Danish authorities require that herds infected at a certain Salmonella level (cf. 5.2.8) are sampled to determine the Salmonella type involved. The veterinary authorities may order special slaughter of herds with high occurrence of Salmonella (cf. 5.2.5).

1.5.7 Control

The SPF breeding and multiplying herds are controlled by veterinarians from the Pig Research Centre during monthly visits, when clinical control is carried out and samples are collected for serological and bacteriological examination for SPF diseases.

In addition, all breeding and multiplying herds are controlled every month for PRRS (Porcine Reproductive & Respiratory Syndrome) and Salmonella by serological testing.

The SPF production herds are monitored by their local veterinarian. Status samples are collected once a year and submitted for serological examination for mycoplasma, pleuropneumonia and, in certain cases, PRRS.

All the records held by the local veterinarian are available to local Contingency Managers from the Danish Veterinary and Food Administration, who supervise their work. The Contingency Managers also supervise individual pig herds and have access to all animal health records. Finally, they ensure that the Health Advisory Agreements with the local veterinarians are properly implemented.

Through VETSTAT, the local veterinarians' prescription of drugs and the herds' use of medicine is monitored.

Every year the Danish Veterinary and Food Administration carry out spot checks on carcasses at the abattoir for presence of residues of antibiotics and chemotherapeutics. If any residues are detected, the Control Officer carries out a formal investigation on the farm, in co-operation with the local police, who interview the farmer in question. Violation of the rules for the withdrawal period may result in financial penalty. If the terms of the Health Advisory Agreement are found to be ignored, the local veterinarian's right to prescribe medicine and the producer's right to treat animals with veterinary medicines may be suspended for up to five years. The industry also levies a fine where antibiotic residues are found in a carcass and in further samples from the farmer's production (see 5.1.1).

The Zoonosis Centre (under the control of the DTU Food, National Food Institute) monitors the development of resistant bacteria related to the use of medicine and other factors. The results of this work are published annually in the DANMAP Report (for more details, visit www.danmap.org).

1.5.8 Summary

Prophylactic use of veterinary medicine is not allowed in Denmark.

Veterinarians may prescribe but not sell antibiotics. However, the veterinarian may hand over veterinary medicine for a maximum of five days usage. The requirement governing prescription medicines ensures that there is clear separation between the prescription and sale of veterinary medicines in Denmark.

Around 90% of producers participate in a formal Health Advisory Agreement, geared to maintaining and improving the animals' health level. The remaining 10% typically experience very few health problems requiring formal intervention, but any medicine used by these producers must be formally prescribed by the veterinarian.

The VETSTAT database enables the Zoonosis Centre to analyse the usage of all veterinary medicine in Denmark, and the data will be used to minimise any unnecessary use in future.

Comprehensive registration of animal health and any medical treatment provides for the detailed documentation of the health status of individual herds.

1.6 Feedstuffs

1.6.1 Legislation and industry agreements

The Danish Ministry of Food, Agriculture and Fisheries is responsible for drawing up legislation on feedstuffs and the current Feedstuffs Act incorporates all relevant EU legislation. The objective of the Act is to regulate trade in feed and including protection of buyers against raw materials and feed mixes of poor quality. The Act states that 'feedstuffs must only be used, if normal use does not constitute a danger to the health of animals and humans or to the environment'. The Act also contains detailed requirements for the content of feed mixes (see Appendix 2-5).

The requirements for feed and feed manufacturers are laid down by the Danish Plant Directorate, covering many specific requirements, including a stipulation to combat Salmonella in feed.

The Danish pig industry made a decision to ban the use of antibiotic growth promoters in feed for pigs in January 2000.

In addition to legislation, producers have adopted a series of Industry Guidelines for the composition of feed, according to the pigs' needs for various nutrients such as amino acids, minerals and vitamins, related to age, weight and production status. Although only guidelines, these are closely observed throughout the industry and communicated widely through the advisory services.

Extensive testing has formed the basis of guidelines for maximum use of certain ingredients in feed for sows, weaners and finishing pigs. For example, it is recommended that the maximum level of iodine in feed should not exceed 70. Recommendations have also been developed for the maximum levels of fat and vegetable oils in feed for finishers: the level of polyunsaturated fats, such as rape or soya oils, should not exceed 1%.

EU regulations require that all feeds must be accompanied by a notice containing information on key ingredients and nutrients in the feed.

1.6.2 Composition of feed

Nutrients: Feed contains a series of nutrients. By chemical analysis, these nutrients can be broken down into: water, crude ash, albuminoids, cellulose and non-nitrogenous extractive substances. In addition to chemical analysis, it is important to establish the presence of energy, amino acids, vitamins and minerals.

Feed Additives: Substances, micro-organisms and preparations that are not feedstuffs or premixed feed and which are added to feed or water for the purpose of one or more of the following functions:

- a) A positive effect on feedstuff quality
- b) A positive effect on quality of animal products
- c) The fulfilment of nutritional needs
- d) A positive effect on environmental implications of livestock production
- e) A positive effect on production yield and welfare by improving intestinal flora or digestibility or
- f) The incidence of coccidiosis or histomonosis.

The iodine number: The iodine number is a standard that expresses content of unsaturated fatty acids in fat. The iodine number of a feedstuff is expressed as the number of iodine units capable of binding 100 g of fat. If the content of unsaturated fatty acids is high in the feed (e.g. from fishmeal), this also results in a high iodine number in fat. It is recommended that the iodine number in fat does not exceed 70 as this may affect the keeping quality of the meat.

Most feeds are a compound of basic raw materials and additives. Feeds are graded according to nutritional content and digestibility. Nutrients are usually divided into water, crude ash, albuminoids (amino acids and other proteins), cellulose (fibre) and non-nitrogenous extractive substances.

Additives are defined as substances or products incorporated in feeds, which influence the properties of the feed or the livestock production itself. They include growth promoting substances, micromineral substances, vitamins and probiotics.

If feeds contain the essential nutrients, then individual ingredients only effect daily gain and production economy, and have little bearing on meat quality. Therefore only guidelines are set for use of particular raw materials, and their use is not subject to official control.

Feeds for sows, weaners and finishers have different nutritional and digestibility requirements. The guidelines for usage of particular feeds are based on the assumption that the nutritional content of the raw materials can be clearly established and remain constant.

The guidelines take into account the following assumptions:

- | | |
|---------------------|---|
| Appetite | Feed intake decreases if it is unappetising or contains harmful ingredients |
| Meat quality | Some ingredients have an adverse effect on taste, colour, consistency and keepability of the meat. For example, the use of fishmeal is not permitted in pigs over 40 kg in weight |

Raw materials The use of similar classes of raw materials in the same feed mix (e.g. use of both coconut cake and palm-oil cake or peas and broad beans) impair product quality, unless each is included in moderate amounts. The limits for maximum admixture are, therefore, often reduced by 25-50%

Other recommendations for producers include:

- Gradual introduction of new feed mixes
- Free access to water
- Care in respect of feed composition.

1.6.3 Raw materials

A typical feed mix for pigs in Denmark consists of barley or wheat and soybean meal. Barley or wheat constitutes between 50% and 75% of the feed mix whereas soybean meal normally makes up 25%. The remaining part of the feed mix may consist of a number of other raw materials such as:

- | | |
|-----------------|---|
| Rapeseed | Up to a maximum of 15% in pig feeds |
| Peas | Primarily used for finishing pigs and may account for 40% of feed mixes. Used rarely |
| Fishmeal | Only used in feed mixes for weaners (up to 40 kg) and normally fishmeal content constitutes less than 10% |
| Fat | Used both as vegetable and animal fat. Fat typically constitutes between 1% and 3% of the feed mix |



Feed for Danish pigs consists mainly of wheat, barley and soybean meal. The use of antibiotic growth promoters in feed has been prohibited since January 2000.

Meat and bonemeal Meat and bonemeal have been banned from use in pig feed throughout the EU.

Catering by-products Catering by-products containing animal protein from land animals are banned

Milk products Primarily used for weaners and normally just skimmed milk, up to 25% of the feed mix.

1.6.4 Standards for nutrients

When evaluating different feedstuffs the following standards are used:

Amino acids

The standard defines the minimum content of amino acids to ensure optimal growth and lean meat percentage. The table below illustrates the significance of lower levels of amino acids, in particular the first amino acids received by the animal.

Significance of the first limiting amino acid		
(5% below standard)	Weaners:	Finishers:
	7-25 kg	25-95 kg
Daily weight gain, g	- 14%	- 15%
Increased feed conversion,		
FUp per kg weight gain	0.04	0.05
Lean meat percentage	-	0.3

Minerals and vitamins

The standards for minerals and vitamins are based on the pigs' minimum requirement and include a safety margin. It is not recommended that minerals or vitamins are added at levels above the standard.

1.6.5 Feed production

Pig feed may be purchased as ready-mixed compound feed or the feed may be mixed on farm (home-mixing). Around half of pig feed in Denmark is manufactured as compound feed, while the remainder is mixed on farm.

Whether in manufacture of compound feeds or home-mixing, the industry's nutrient standards must be followed, to ensure wholesome feed for optimal growth and exploitation of the pigs genetic predisposition for a high lean meat percentage.

Admixture

From January 1st 2006, the EU's feed hygiene regulations (1831/2003) require all farms to be formally registered with the Danish Plant Directorate. Farms that manufacture feed with an admixture of pure additives or premixes must be registered as HACCP herds and, like the feedstuff industry, follow a quality assurance system that complies with the HACCP principles (HACCP: Hazard Analysis and Critical Control



Feed is either bought in as compounds or mixed on-farm. Today around 50% of pig feed is 'home mixed' by the producer.

Point). Farms that use ready-mixed feed or produce feed using supplementary ingredients or mineral feed mixes must be registered in accordance with the rules concerning good manufacturing practice (GMP).

Salmonella

The Danish pig industry has prepared a series of guidelines to limit the development of Salmonella in pig herds.

The Ministry of Food, Agriculture and Fisheries states that feed manufacturers must have measures in place to eliminate Salmonella from feed (Regulation No.1177/2007). Most feedstuff companies heat-treat feed to at least 81 °C in order to meet this and other requirements laid down in the regulations. Salmonella-contaminated raw materials

must also be heat-treated to at least 81 °C. Therefore, all feed purchased by Danish pig producers is covered by a control system for the content of Salmonella.

Guidelines are also followed with regard to increased hygiene in silo and feeding systems so as to safeguard against Salmonella contamination. Home produced grains and peas do not constitute a high risk from Salmonella contamination, providing proper steps are taken to avoid infestation by rodents, birds and pests. Raw materials such as fats, food industry co-products, whey, fish pulp, molasses and fishmeal are considered and treated as ingredients which potentially present high Salmonella risk, and must be stored correctly.

1.6.6 Feeding systems

The choice of feeding system depends on whether dry or wet feed is used and whether feeding is restricted or ad libitum.

Dry feed may be given as meal or pellets. Pigs consume pelleted feed nearly twice as fast as meal based feed, but wet feeding allows the most rapid feed intake.

The choice between restricted or ad libitum feeding depends on factors such as weight gain, lean meat percentage and feed consumption.

A rise in the weight gain may increase the number of pigs produced per pen place, while extra gain is not considered economically significant if there is plenty of space available in the finishing unit. The feed price and the scale of charges and deductions levied at the slaughterhouse also play a role. The producer will choose his type of feeding regime based on type of pig, the housing system and feed sources available.

1.6.7 Control

The Plant Directorate is responsible for ensuring that feeds meet the specified standards for content of nutrients, additives and other ingredients.

A number of EU approved chemical and microbiological analytical methods are used.

Using microscopic botanical analysis, the Plant Directorate are able to establish whether the composition of a feed meets the specification described on its label or accompanying notice or whether raw materials have been used that are not described on the label. The EU has defined tolerances for how much a control analysis may deviate from the declared content of nutrients in the feed. Control and analysis results are published in quarterly reports. In this way, assessments are

carried out on an ongoing basis as to whether the feed companies have mixed the feed correctly.

Feedstuffs manufacturers receive at least two control visits per annum. The number of samples collected for analysis depends on the amount of feed produced. The Plant Directorate makes their choice of samples linked to higher risk feeds and raw materials. Sampling is not conducted on a random basis and this must be borne in mind when interpreting the results. Unwanted substances are described in the Appendix (Nos 2 and 4), as well as threshold values for content in raw materials and feed. Only official and approved analytical methods are used and the control and analysis results are published in quarterly reports with individual companies named (see www.pdir.dk).

The Plant Directorate's control of additives in feed consists in part of account-based controls on consumption and in part of random sampling at manufacturers and distributors.

Only official and approved analysis methods are employed and the control and analysis results are published in quarterly reports along with the company name.

The Plant Directorate test feed samples for Salmonella contamination and carry out inspection of production lines and again the results are published on a quarterly basis (see www.pdir.dk).

In addition, the Plant Directorate visit around 5% of all herds in Denmark each year, to ensure correct procedures are being observed by home-mixers.

Ready-mixed feeds are also assessed at the industry's own test farm. Different feed mixes for weaners and finishers are tested in growth trials and their impact on productivity is assessed. Feed mixes are

purchased without prior knowledge of the companies involved and thus provide an independent and objective assessment of products available for producers. Around 15-20 commercial finishing and weaning feeds are tested annually.

1.6.8 Summary

The official control of feed production in Denmark covers composition, content of nutrients and additives in feed as well as presence of unwanted substances. This ensures a continuous check on the quality of feed used in pig production and that there are no unwanted residues in meat. It also ensures that manufacturers produce feed which meets specifications laid down between buyer and seller.

Introduction of Salmonella to herds via feedstuffs is minimised by the control programme described above. The fact that all analysis results are put in the public domain ensures a quick reaction from the producer where feed suppliers are falling short.

Official control is supplemented by advice and guidance on quality standards that benefit the taste of Danish pork. By observing these guidelines, producers can combine production efficiency as well as producing high quality livestock.

2 Transport and pre-slaughter treatment

Chapter 2 describes the transport, lairaging and stunning of pigs at the abattoir. These processes are crucial to meat quality and, animal welfare. The integrated production system in Denmark ensures good coordination between the pig producer, the haulier and the co-operative slaughterhouse.



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2.1 General

The proper treatment of pigs during collection, transport, at the lairage and prior to stunning at the slaughterhouse have a major impact on meat quality as well as meeting the industry's responsibilities in showing due consideration for the welfare of the animals in their charge.

For many years, the industry and the authorities have sought to improve the treatment of animals at this critical stage. This has resulted in improved collection from the farm, well-designed transport vehicles and a highly organised transport system as well as improved systems for the lairaging and stunning of pigs at the abattoir.

Pigs are delivered directly from the producer to the slaughterhouse. There is a close coordination between the pig producer, the haulier and the abattoir and a Code of Practice is followed which exceeds legal requirements. The Pig Research Centre provide comprehensive information to assist producers in assessing their animals before they are sent for slaughter (Appendix 6).

2.1.1 Producers

Traditionally, when a pig producer became a member of a co-operative slaughterhouse, he made an undertaking to deliver all his pigs to the group. In return, the slaughterhouse committed itself to accept all the pigs delivered by the producer. More recently it became possible for a producer to deliver up to 20% of his pigs to another abattoir.

The producer may choose to transport his pigs to the abattoir himself or the slaughterhouse may arrange transport on his behalf.

2.1.2 Haulier Agreements

The slaughterhouse is responsible for the coordination of the transport of pigs to the abattoir, so deliveries of pigs are spread throughout

the day. The slaughterhouse has a contract with each of its appointed hauliers.

The contract includes a fixed price as well as the geographical area to be covered. As a part of the agreement, producers may obtain a transport deduction per pig if a large number of pigs are collected together or if the pigs are collected at night. Good collection facilities and loading conditions enhance animal welfare and ensure an effective delivery system and are rewarded by reduced transport costs.

Each haulier is given a specific area, consisting of a fixed number of pig producers. This system ensures continuity between an individual haulier and producer.

2.1.3 Haulier License

Hauliers must be licensed to transport pigs. The authorisation is issued by the Danish Veterinary and Food Administration.

Drivers of animal transport must understand the needs of animals during transportation and must have received adequate training in the subject at special transport courses. By ensuring that all drivers are familiar with the animals' behaviour and requirements, the pigs are assured of the best possible transport. By 2003, all hauliers had completed formal training and regular updates are held to keep them abreast of the new legislation.

Since 2007, it has been a legal requirement that everyone involved in handling animals during transport should receive basic training in the transport of animals. The training covers the rules and regulations within this field. In addition, the drivers and their colleagues receive specific training for one or several species. This additional course is also known as Certificate of Competence training. The certificate,

which is exam-based, is awarded by an independent body authorised by the Danish Veterinary and Food Administration. The Certificate of Competence has been a requirement since 5th January, 2008.

Vehicles for the transport of pigs must be approved by the Danish Motor Vehicle Inspectorate and the industry has adopted the guidelines set out in HST (Handbook on Pig Transport) for all new vehicles being built to ensure compliance with all the latest knowledge and best practice.

2.1.4 Journey distances

The co-operative system ensures that the majority of pigs from a single producer are delivered to the same slaughterhouse, which also ensures the shortest possible journey time. Usually, the distance from the farmer to the slaughterhouse is less than 50 km and only in a few cases over 100 km. Transport times are less than three hours for 95% of all animals transported to Danish abattoirs.

2.1.5 Control

The transport of pigs is controlled by a special authority – The Board for Animal Welfare during Transport. This Board includes representation from the police and the appropriate veterinary authorities. At the abattoirs, during lairage and stunning, control is the responsibility of The Danish Veterinary Service.

The Danish Motor Vehicle Inspectorate approves and ensures that transport vehicles meet all legal requirements.

Random checks on animal transporters, to check loading densities and the condition of the vehicles are carried out as part of the remit of The Board for Animal Welfare during Transport.

The Danish Veterinary Service and the slaughterhouses are responsible for ensuring that the vehicles are properly cleaned and not overloaded and that the animals are fit for transport.

When the pigs are offloaded at the slaughterhouse, their condition is checked in accordance with EU regulations (854/2004/EC). In addition, The Danish Veterinary Services supervise the operation of lairaging and stunning facilities.

2.1.6 Summary

The Danish system delivers well co-ordinated transport of pigs for slaughter, including their lairage and stunning. It is based on the following:

- Short transport distances
- Fixed agreements between hauliers and slaughterhouses
- Producers' pigs delivered to the same abattoir (at least 80% of all pig deliveries)
- Producers' pigs collected by the same haulier
- Considerate treatment of the animals.

These factors ensure that the following apply:

- Maximum protection against the spread of disease during transport
- Good welfare during the pre-slaughter handling of pigs
- Low mortality during the transport and lairaging of pigs.

2.2 Collection

This stage concerns the manner in which pigs are transferred and held in special facilities on-farm prior to collection and delivery to the abattoir.

2.2.1 Legislation and industry agreements

The collection facilities for pigs must comply with the relevant Danish legislation (Act No. 104/2000 for weaners, breeding pigs and finishers, and Act No. 404/1998 for pregnant sows and gilts) and subsequent amendments.

The loading of pigs must also comply with the relevant EU requirements (EU No. 1/2005), regarding the welfare of animals during transport, as well as the requirements of other directives (64/432/EC and 93/119/EC) and regulations (EU No.1255/97).

Danish legislation also requires that on departure pigs must be clearly marked to allow the identification of the producer.

To avoid spread of disease, the industry has adopted a set of guidelines for the design of the collection area on-farm as well as rules for delivery of pigs to the slaughterhouse. Producers may access the guidelines on www.infosvin.dk.

2.2.2 Supplier number marking

Before delivery to the slaughterhouse, pigs are tattooed with a five-digit supplier number on each gammon (see section 5.5.1). This marking ensures that the slaughterhouse can identify the supplier of each animal.

If the tattoo is illegible, or if more than two digits are missing, DKK 20.00 is deducted from the price the producer receives.

2.2.3 Collection systems

To prevent spread of disease between herds and to ensure considerate treatment of the pigs at the time of delivery, most farms have now established special collection facilities.

There are four types of collection arrangements:

- Collection pens
- Special delivery vehicles
- Collection points
- Direct delivery.

Collection pens

When using collection pens, the pigs are moved to a separate housing unit, which is isolated from the rest of the herd.

Special delivery vehicles

These are mobile collection pens. The pigs are loaded directly onto the delivery vehicle, taken away from the herd to a specific location and loaded onto the transport vehicle. This minimises contact between the herd and the transporter. The pigs may be held for a maximum of two hours in these delivery vehicles. This kind of facility is used less frequently today.

Collection points

The collection point is a delivery area to which the pigs are taken immediately before loading and serves as prevention against disease spreading to the remaining pigs.

Direct delivery

For a direct delivery, pigs are taken directly from the pens to the transport vehicle. The respective housing section is temporarily isolated from the remaining pigs.

For collection facilities non-slip ramps or concrete platforms are usually installed. Good loading conditions enhance animal welfare and ensure an effective delivery system.

Use of electric goads is not permitted at this stage.

2.2.4 Disease prevention

By observing the following guidelines, the farmer can safeguard his herd against any disease transmission from the transport vehicle:

- The collection facility must be clearly separated from the other housing units, which also applies to equipment and employees
- Effective cleaning and disinfection must be carried out after each delivery of pigs
- Drains and slurry pipes in the collection area must not be directly connected to other housing units
- The haulier must only enter the collection facility.

2.2.5 Control

Specialist pig advisers are able to assist the farmer in the design of his collection facility (c.f. section 1.1.5) The industry has introduced guidelines for the design of the collection room as well as special regulations for the delivery of pigs. Good collection facilities and loading conditions enhance animal welfare and ensure an effective delivery system and are rewarded by the slaughterhouses with reduced transport costs. These factors encourage good animal welfare and minimise the risk of disease transmission.

The Danish Veterinary Service checks that the pigs only have one tattoo on each hindquarter. If any pig has more than a single tattoo on each hindquarter, this represents a breach of legislation and follow-up action is taken.

2.2.6 Summary

Collection facilities are designed with a view to disease prevention, a high standard of animal welfare and an effective delivery system. Additionally each pig producer has access to specific guidelines on delivery of pigs prepared by the Pig Research Centre.

The following recommendations will ensure minimum stress and maximum comfort during delivery:

- Reducing the mixing of pigs from different pens to a minimum
- Loading the pigs in a considerate manner
- Ensuring a low stocking density in the collection facilities
- Installing solid non-slip loading platforms.

Proper and considerate handling of pigs also minimises the risk of PSE and skin damage.

Tattooing with the supplier number makes it possible for the slaughterhouse to identify the origin of each animal.

2.3 Transport and lairaging

This stage covers transport from the farm, unloading and holding of pigs in the lairage at the abattoir.

2.3.1 Legislation and industry agreements

The transport of pigs and the instruction of hauliers is controlled by the relevant EU regulations (EU No. 1/2005) which also lay down requirements for all those involved in transporting animals. On the basis of EU regulations, the Danish Ministry of Justice has implemented national regulations which go beyond the EU requirements for transporting animals (Regulations No. 1728/2006 and No. 1729/2006).

Requirements for the design of lairages at the slaughterhouse, as well as the handling of pigs before stunning, are laid down in Danish legislation, which also implements EU regulations (91/119/EEC).

According to the EU regulations (854/2004/EC) for food of animal origin, pigs must be formally examined by a veterinarian no later than 24 hours after arrival at the slaughterhouse and a maximum of 24 hours before slaughter.

In addition, the Danish Meat Research Institute has drawn up a number of additional guidelines to be followed at this stage to ensure good meat quality. These cover best practice from the time the pigs are collected to final stage of the despatch of primal cuts from the slaughterhouse (Appendix 7). Special training in animal welfare of employees working in the lairage and stunning area is required by the slaughterhouses.

2.3.2 Delivery registration

A producer delivers pigs for slaughter on a fixed day of the week. Most pigs are transported by appointed hauliers, but a few producers choose to transport their animals to the slaughterhouse themselves.

Typically, producers register pigs for delivery on-line with the slaughterhouse on a Thursday during the week prior to slaughter.

The slaughterhouse is then responsible for the coordination of transport, so that this is distributed evenly over the whole day and any unnecessary waiting time is avoided. This is achieved by informing each driver of the time intervals during which the pigs must be delivered to the slaughterhouse.

Around 80% of the hauliers are contracted to deliver pigs to the same abattoir, while the remainder are informed of the place of delivery for each group of pigs according to particular circumstances.

2.3.3 Transport

To ensure considerate treatment of animals, transport vehicles are equipped with proper loading facilities, non-slip floors and mechanical ventilation.

In addition, the following guidelines must be followed:

- Maximum of 15-20 pigs in each compartment of the vehicle
- No vehicle overloading
- Careful driving with no unnecessary stops
- Local agreements on delivery must be observed
- Drive boards used for moving pigs
- All vehicles cleaned before leaving the slaughterhouse.

Collection must be organised so that the haulier picks up pigs from the herd with the highest health status first. Animals from herds with higher levels of Salmonella infection are transported and slaughtered separately under increased hygienic conditions.



To minimize the risk of any disease spreading all transport vehicles must be cleaned and disinfected after unloading and before leaving the slaughterhouse.

If producers deliver pigs to the slaughterhouse themselves, transport documentation is also necessary and the transport has to conform to the same standards as required for external hauliers. Around 5% of finishers are delivered to the slaughterhouse by producers themselves.

Before arrival at the farm, the haulier notifies the producer to ensure that the pigs are ready for delivery. The risk of disease transmission is therefore minimised, since contact between the transport vehicle and the herd can be avoided. It also ensures good working practice and consideration for the welfare of the animals to be collected.

Before departure, the driver must check that all pigs are fit for transport. Any sick or injured pigs may only be transported under special conditions. Animals that are unable to walk or stand may not be transported. If an injured or sick animal is able to walk onto the truck by itself, it may only be transported if it is kept separately from the other pigs. As a rule, only healthy pigs are transported to the slaughterhouse.

For each journey, a document is issued stating:

- Place of departure and date
- Time of transport (departure and arrival)
- Number of pigs transported
- Herd or origin
- Destination.

Upon arrival at the slaughterhouse, the driver stamps the documents and passes them to the representative of the Danish Veterinary Service.

After unloading at the abattoir, the transport vehicle must be cleaned, and disinfected.



To ensure considerate handling of animals during transport, all vehicles are equipped with proper loading facilities, non-slip flooring and mechanical ventilation systems. The veterinarian inspects all pigs at the slaughterhouse during unloading. The use of electric goads is not permitted during the unloading and lairaging of the pigs.

2.3.4 Lairaging

The slaughterhouses have adjustable, slip-resistant off-loading ramps, which make the unloading of pigs easier and provide them with additional protection. Electric goads must not be used during unloading

and lairaging, and all pigs must be allowed to move of their own free will wherever possible.

During unloading, the veterinarian examines all the pigs while moving, so that any injuries may be detected more easily. Pigs injured during transport receive treatment or are killed immediately.

All abattoirs keep a record of the number of pigs which each transport vehicle is allowed to carry. By checking this documentation, the veterinarian ensures that vehicles are not overloaded.

After the veterinary inspection, the pigs are led into lairaging pens where they remain for approximately one hour before slaughtering. The pens are well-ventilated with drinking-water facilities. In addition, the lairage is equipped with a misting system to cool pigs in hot weather. This meets the requirements for animal welfare as well as ensuring good meat quality by minimising stress.

If pigs are housed at the abattoir overnight, they must be fed and tended. If they remain at the abattoir over the weekend, they must also be fed and attended to on a daily basis.

2.3.5 Control

All transport vehicles are licensed by the Danish Motor Vehicle Inspectorate and the licence must be kept in the vehicle.

By inspecting the license of the transport vehicle and the accompanying documentation, the veterinarian checks that the pigs have been properly transported. All dead or injured pigs are recorded.



The veterinarian ensures that all welfare requirements are fully observed. Pigs are examined as they are unloaded from the vehicle. While the pigs are moving, any injuries can be easily detected. Any pigs injured during transport are treated or killed straightaway.

If any aspect of transport is found to have been unacceptable, the haulier is formally advised. In more severe cases, the police may be informed or the haulier may have his licence withdrawn.

In addition, the veterinarian carries out random checks to ensure that:

- Vehicles are not overloaded
- Vehicles are cleaned and disinfected before leaving the slaughterhouse
- Pigs are housed in proper conditions.

According to EU regulations (854/2004/EC), the veterinarian must carry out a visual inspection prior to slaughter. Normally, pigs are

examined as they are unloaded from the vehicle. If the pigs stay overnight in the lairage, the veterinarian examines them again immediately before slaughter. Special pens for sick animals are available in all slaughterhouses, enabling closer examination of these animals.

The veterinarian ensures that all welfare provisions have been observed. This includes visual inspection of the pigs in movement to identify those with any lameness or visible injuries. This inspection will determine whether the animals are sick, exhausted, aggressive or showing other disorders. Pigs suspected of being sick or medicated must be closely examined so a formal diagnosis may be made. If it is necessary to examine the animal after slaughter to obtain a correct diagnosis, then the pig must be slaughtered separately.

The veterinarian checks the operation of the lairage daily to ensure that all pigs have access to fresh water, that the equipment is properly working and that the general conditions under which the pigs are held ensures their welfare is given proper consideration.

2.3.6 Summary

Proper delivery, transport and housing of pigs will result in the following:

- Minimal injuries
- Good welfare
- Minimum risk of disease spread
- Low stress levels resulting in good meat quality
- Full traceability.

The requirements for the cleaning and disinfection of transport vehicles at the slaughterhouse also minimise the risk of disease spread.

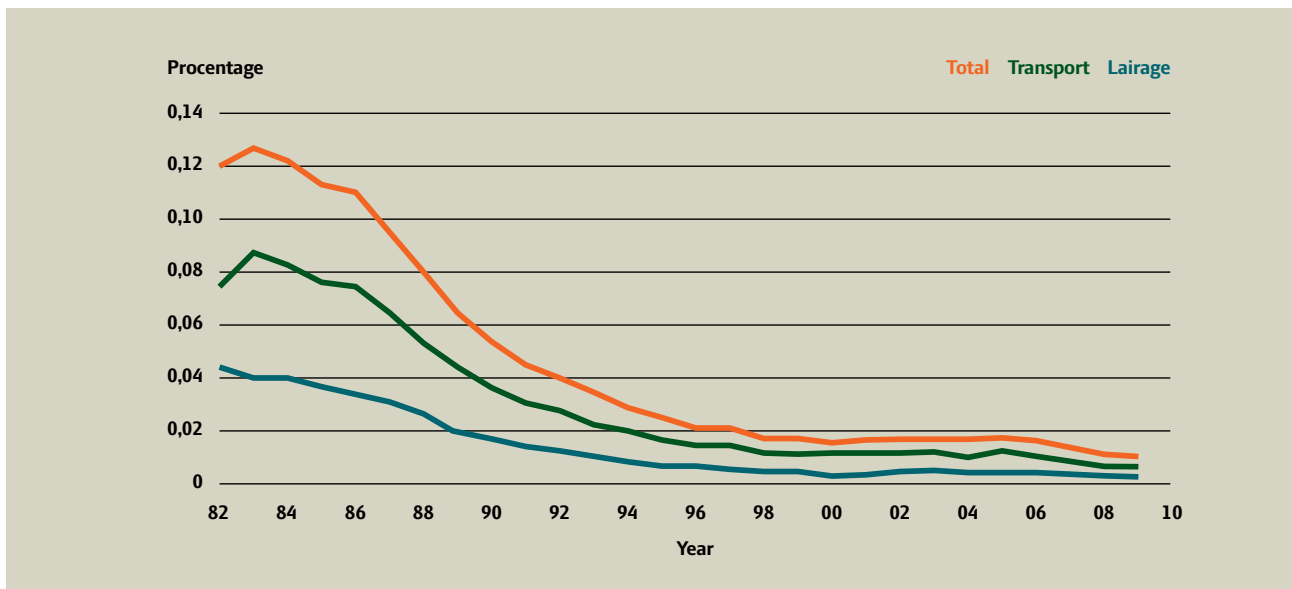


Figure 7: Mortality of pigs during transport and lairaging in Denmark (Source: the Danish Meat Research Institute)

Together with the short transport distances to slaughterhouses and transport vehicles that, in several respects, exceed legislative requirements, the improved handling of pigs has reduced the level of mortality during transport and lairage to just 0.011% in 2009, the lowest in Europe.

2.4 Stunning



A new system of stunning pigs has now been introduced at most Danish slaughterhouses. The pigs are stunned in groups of 5-8, having passed through a series of automated gates, which allow free will and unforced movement of the pigs. Around 90% of Danish pigs are now stunned in these group systems prior to slaughter.

2.4.1 Legislation and industry agreements

EU and Danish legislation requires that all pigs must be anaesthetised before sticking (Regulation No. 583/2007).

2.4.2 Stunning

The pigs are stunned using a mixture of air and CO₂ (85-90% CO₂).

A new group stunning system has been introduced in many slaughterhouses in Denmark, which allows free and unforced movement of pigs. In this new system, the pigs are gently led to the stunning chamber in groups of five to eight animals, through a passage using automated gates. After stunning, the pigs are tipped out ready for shackling and sticking. Around 90% of Danish pigs are now stunned in group systems.

In the older systems, pigs are led into the stunning area via a manually operated gate. When the entrance gate closes, the stunning is started manually. The pigs are then lowered down into the CO₂ atmosphere where they lose consciousness and are then tipped out ready for shackling and sticking.

CO₂ stunning is used in Denmark because it achieves the following:

- Effective system operation
- Possibility of group handling
- No use of electric goads (in the group system)
- Minimum discomfort for the animal
- Neutral effect on meat quality
- Improved safety for employees.

The pigs' exposure to carbon dioxide during stunning must be adequate to ensure the pigs remain unconscious until death via bleeding. The stun-to-stick intervals used at co-operatively-owned slaughterhouses correspond to European guidelines (European Food Safety Authority: EFSA – AHAW/04-027) and focus on ensuring that proper procedures for stunning have the highest priority.

Total time of exposure (sec)	Sticking within (sec)
120	30
130	45
140	60
150	75
160	90

Source: European Food Safety Authority – AHAW/04-027

The stun-to-stick intervals are based on an air composition, with a minimum 70-80% CO₂ when pigs first arrive in the chamber, increasing to a level of 90% CO₂ at the base of the chamber. With higher average concentrations, the times for sticking can normally be extended.

2.4.3 Monitoring and control

The veterinarian continuously checks that the CO₂ stunning is performed in a proper way. At start of production and at intervals during the day, inspectors from the veterinary authorities check the stunning processes and that the CO₂ concentration is high enough to anaesthetise the pigs properly.

2.4.4 Summary

General

The industry considers the use of CO₂ to offer the most welfare friendly stunning method. The replacement of electric stunning with CO₂ stunning has led to a halving of the PSE frequency (see 1.2.5) and a reduced occurrence of blood splashing and broken bones.

Blood splashing

With electrical stunning, blood splashing appears particularly in loin and ham, as a result of rupture of blood vessels. CO₂ stunning has led to a 75% reduction in the amount of blood splashing compared to that experienced in electrical stunning. Also, the risk of broken bones following application of the electrical stun is eliminated when using the CO₂ method.

PSE frequency

The PSE frequency in Danish pork is extremely low (below 2% in loin and 4% in ham). The main reasons behind this development are that:

- Pigs with stress sensitive genes have been removed from the breeding system
- Transport of pigs to the slaughterhouse and lairaging of pigs is organised as considerately as possible
- Pigs are CO₂ stunned
- Pigs are rapidly cooled after slaughter so the rate of the pH decline is reduced (see section 3.11 on cooling).

3 Slaughter

Chapter 3 covers the slaughter of pigs and commences with a description of the hygiene conditions at the abattoir and training of slaughterhouse personnel. Personnel involved in cutting and boning also receive hygiene training. All processes from the sticking of pigs to chilling of carcasses are described in detail linked to the guidelines followed by personnel at the abattoir.





3.1 Background

The process of slaughtering pigs is carried out in a fairly uniform manner at the ten co-operative slaughterhouses in Denmark. This is due to the commitment to common quality objectives over a long period of time.

As a rule, only gilts and castrates are used for fresh meat. Entire males are used for special products where the risk of boar odour is not a factor. The slaughter of sows takes place on special slaughter lines but does not differ significantly to that for other categories of pigs.

The whole of the slaughter process is based on a self-audit programme linked to HACCP principles (Hazard Analysis and Critical Control Points). As regards requirements for documentation, all co-operative slaughterhouses in Denmark have now implemented The Global Red Meat Standard. The standard covers both slaughterhouses and cutting plants and the whole production process is fully documented, from approval of suppliers, through the processes themselves, training and sales. The standard primarily focuses on food safety, animal welfare, traceability and environmental matters and the current version is available at www.grms.org.

3.1.1 Slaughter process

The slaughter process in Denmark meets the requirements laid down by EU regulations relating to the hygiene of foodstuffs (852/2004/EC) and specific hygiene rules for food of animal origin (853/2004/EC). However many of the processes used also have their own unique features.

Usually between 300 and 420 pigs are slaughtered per hour on each slaughter line. The slaughtering and cutting of the carcass takes place with rind on.

The slaughter of pigs is divided into an 'unclean' and 'clean' section kept separate for reasons of hygiene. In the 'unclean' section, the pigs are stuck, bled, and the rind of the carcass is treated. In the 'clean' section the carcasses are eviscerated, split and then, examined by the Danish Veterinary Service, and finally weighed and graded.

The process achieves a high hygienic standard due to careful implementation of all operations and effective carcass chilling. All processes are carried out by skilled personnel under careful supervision to meet the demands for quality and hygiene.

Processes in Danish slaughterhouses and a demanding standard of hygiene and effective production control ensure high quality pork products. This objective is also achieved through adherence to a series of detailed industry guidelines (see Appendix 7).

3.1.2 Control

Official control is carried out by the Danish Veterinary Service, which consists of veterinarians and inspectors employed by the Danish Veterinary and Food Administration. The inspectors are managed by a head veterinarian.

The control includes the following:

- Visual inspection of live animals (cf. section 2.3.5)
- Inspection and approval of carcasses for human consumption (cf. section 3.8)
- Approval of equipment and facilities
- Routine hygiene control
- Random testing for residues and other substances
- Surveillance of the company self-audit systems and HACCP.

On behalf of the Ministry of Food, Agriculture and Fisheries, the Danish Pig Classification Authority controls the weighing and grading of animals as well as the payment to producers. This organisation is also charged with other tasks such as training of the abattoir personnel as well as collection of meat samples for Salmonella control (See Section 3.10.5.)

In addition, a national programme of screening of pig carcasses for Salmonella is conducted (See Section 5.2).

All companies have implemented extensive quality control procedures as well as a self-audit programme.

3.1.3 Summary

The uniform structure of the cooperative slaughterhouses in Denmark combined with their self auditing systems and official veterinary inspections ensure that pork from Danish slaughterhouses is approved for human consumption and produced in accordance with the highest food safety standards. All slaughter processes are organised to ensure that high hygienic standards are maintained and potential food hazards are minimised.

All Danish co-operative abattoirs are approved by the US Department of Agriculture (USDA).

3.2 Hygiene and microbiology

3.2.1 Legislation and industry agreements

The control of the production of fresh pig meat for human consumption is carried out in accordance with EU regulations laying down specific hygiene rules for food of animal origin (853/2004/EC) and rules for the organisation of official controls on products of animal origin (854/2004/EC) and residue surveillance (96/23/EEC).

Slaughterhouse companies have introduced a self-audit programme for hygiene and veterinary residues, in accordance with EU regulations laying down specific hygiene rules for food of animal origin (853/2004/EC), rules for hygiene of foodstuffs (852/2004/EC) and residue surveillance regulations (96/23/EEC). They all meet HACCP requirements as stipulated by the US authorities (Food Safety and Inspection Service (FSIS), USDA).

3.2.2 Hygiene and microbiology

Bacteria:	Bacteria types
Bacterial count:	Bacteria per cm ² or per gram meat

The essence of meat hygiene is the avoidance of contamination of meat by bacteria and other unwanted substances and measures to prevent the growth of undesirable bacteria.

Bacteria may derive from a pig's skin, mouth, throat, stomach or intestine (enterobacteria) or from the surroundings (environmental bacteria). Some enterobacteria are pathogenic (e.g. Salmonella).

It is important to determine which bacteria are present in meat. A single pathogenic bacterium may be dangerous in an environment with a low germ presence, where it may easily multiply, compared to an environment abounding with germs, where it may have greater

difficulties in surviving the competition from other less harmful bacteria. Therefore, good microbiological hygiene does not simply depend on a low bacterial count, but also the presence of different types of bacteria may be a significant factor.

The aim of a large proportion of the co-operative slaughterhouses' work within hygiene procedures is to reduce contamination of meat and meat products from pathogenic bacteria and to map and control hygiene conditions through the production chain.

The most important measures taken to prevent spread of bacteria are as following:

- Establishment of the health status of pig herds
- Thorough training of personnel in hygiene practice
- High standards of personal hygiene
- Good working routines on the slaughterlines
- Effective and rapid chilling of the carcasses.

High standards of hygiene are ensured through extensive control procedures (cf. below and section 5.1).

3.2.3 Company self-audit procedures

Self-audit: Comprises the systematic actions taken by the company to ensure that its products do not involve health risks and that legislation on food safety is observed.

All the industry's co-operative slaughterhouses have implemented self-audit programmes in accordance with HACCP principles. The



As part of the companies' own self-audit procedures, microbiological samples are taken after cleaning and hygienic procedures have been carried out. These samples are then analysed in the companies' own approved laboratories.

purpose of the programme is to ensure that all food products pose no risk to human health.

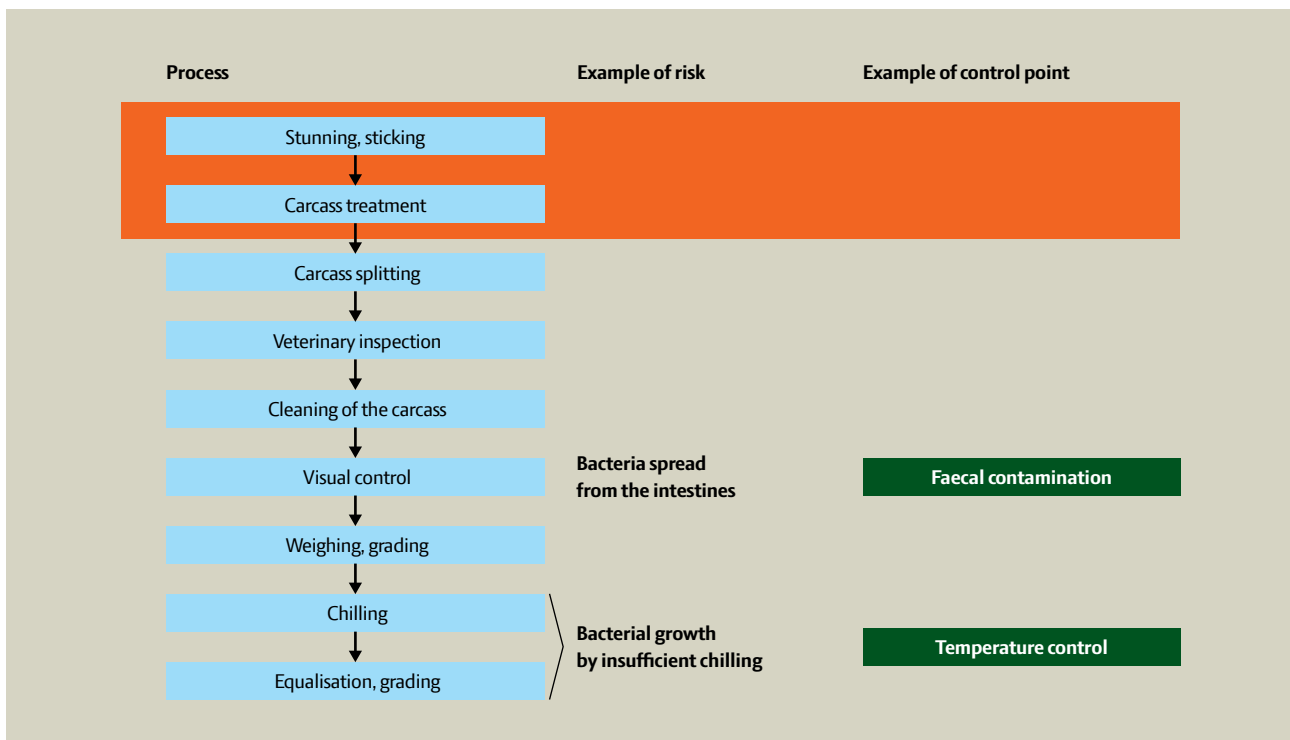
The self-audit programme is designed individually for each company and covers the following areas:

- Raw materials
- Production
- Finished products
- Cleaning and disinfections
- Personal hygiene.

The programme must be audited by the Danish Veterinary and Food Administration.

The programme is based on the following elements:

- Product specification
- Flow diagrams
- Risk analysis according to HACCP principles
- Determination of controllable risks, Critical Control Points (CCPs)
- Determination of the critical limits for each CCP



- Establishment of effective monitoring procedures for CCP
- Determination of all necessary corrective action if critical thresholds are exceeded
- System testing
- Documentation.

The companies have carried out these procedures for several years by means of quality management where each company has described its process flow and through risk analysis identified CCPs in the production chain.

Risk

The production environment can result in the risk of contamination from pathogenic bacteria. The Danish pig industry has drawn up a list of possible chemical, biological and physical risks for fresh meat of Danish origin as well as for various processed products (see 5.1). The companies then use this information to conduct their own risk assessment. Once the processes involving hazards are identified the areas in the production flow are established where risks can be controlled (CCP's). The figure above shows some examples of risks and critical control points in the production chain.

Monitoring critical control points

An effective monitoring procedure is established for each CCP, which includes the frequency of monitoring and critical limits. Surveillance procedures have been developed so they can be easily integrated in the day-to-day running of the production line.

Procedures are established for the necessary corrective actions to be taken when a fault is identified, as well as clear delineation of individual responsibilities in implementing the HACCP programme.

Testing

To ensure that the critical limits are acceptable, the effectiveness of the monitoring procedures must be tested. The system is mainly controlled by microbiological analysis or visual inspection.

When changing production, or at least annually, the company reviews the risk analysis and the monitoring procedures for the entire production. The continuous updating of the self-audit procedure ensures that the risk analysis is as robust as possible and the latest knowledge is incorporated in the system.

3.2.4 Role of the authorities

The Danish Veterinary Service supervises the whole of the companies' approved self-audit programme by both pre-arranged and unannounced inspections. During the pre-arranged visit, each part of the programme is systematically examined. Testing of the self-audit programme includes the following:

- Examination of the CCP's with critical limits and corrective actions
- Visual inspection of operations and processes

- Examination of discrepancies recorded and the corrective action taken
- Additional random tests and analyses.

A detailed report is then compiled, and this ensures that the company self-audit programme fully complies with its stated objectives.

3.2.5 Summary

By tailoring the self-audit programme to the specific production conditions in each company, all food safety risks are mapped out and subjected to continuous control. In addition, the independent checks carried out by the Danish Veterinary Service of the companies' monitoring procedures, ensure that high standards of food safety are achieved.

3.3 Employee training and motivation

3.3.1 Legislation and industry agreements

By implementing EU regulations on the hygiene of foodstuffs (852/2004/EC), the companies ensure that all personnel handling foodstuffs receive proper training in food hygiene which is tailored to the tasks undertaken.

3.3.2 Danish Meat Trade College

The Danish Meat Trade College in Roskilde is run as a public institute of education, which offers the slaughterhouse companies a wide range of relevant training courses, and trains about 20,000 people annually from the whole food industry in Denmark.

3.3.3 Hygiene training for employees

Basic training programmes have been developed to educate all slaughterhouse employees in correct hygiene procedures. The training aims to motivate employees to follow the rules and requirements established both by the company itself as well as the Danish authorities. It is also important that every employee understands the need to consult his manager or the veterinary inspector, when there are production irregularities or regulations are unclear.

The training must ensure that all employees:

- Understand the necessity of following the hygiene instructions for all work processes
- Realise the importance of good personal hygiene
- Obtain basic knowledge about microbiology, including growth conditions for bacteria, presence of bacteria, contamination of food products, contamination sources and keeping quality of different food products
- Understand the importance of correct working routines affecting the spread of food borne disease
- React adequately in the case of production irregularities.

Below is an example of a typical training programme for new employees.

All employees must wear special clothing provided by the company and must not wear watches, jewellery or any other loose items in the workplace.

3.3.4 Hygiene training for managers

Hygiene training for managers involves a three day course. The training gives managers a better understanding of the correct hygiene conditions for the production of safe food products. After the course, managers will be able to make a positive contribution to the planning of production procedures at the hygienic levels required in an export licensed abattoir. The managers will also be qualified to instruct their fellow employees in personal and production hygiene.

During training, particular attention is given to the subject of contamination and the growth of bacteria during production. The training is organised to enable managers to understand requirements for hygiene in the context of the daily working environment.

The training must ensure that the manager understands the following areas:

- Bacteria and their growth conditions
- Importance of personal hygiene and the risk of contamination from person to product.
- Production hygiene and contamination from equipment, tools and machinery and especially cross-contamination between products
- HACCP and the self-audit procedure
- Relevant legislation on food safety and the importance of following regulations

General instruction

First day of employment

Information about the company and the regulations that apply to an export licensed abattoir

Introduction

Maximum one month after start of employment

Hygiene

Personal hygiene
Microbiology
Bacterial growth
Germ reservoirs
Contamination of meat
Sources of contamination
Keeping quality
Health examination

Follow-up training

Maximum four months after start of employment

Foodborne diseases

Foodborne diseases
Infections
Food-poisoning
Salmonella
Yersinia
Campylobacter
Listeria
Soil bacteria
Refresher courses
(Content varies according to department)

Department meetings

Hygiene problems related to daily work are discussed during routine departmental meetings.

- Role of official veterinary inspection
- Need to motivate all employees to follow good hygiene practice.

3.3.5 Summary

Good hygienic practice is a pre-requisite for production of safe food of good quality. It is vital that all employees understand the importance of maintaining good hygiene. The proper training of employees ensures that these principles are understood and thus makes a significant contribution to good hygiene practice in Danish co-operative slaughterhouses.

3.4 Sticking, bleeding and blood collection



After stunning by CO₂, sticking and bleeding take place by cutting the carotid arteries without the animal regaining consciousness.

3.4.1 Legislation and industry agreements

The collection of blood from pigs following slaughter is carried out in accordance with the EU regulations laying down specific hygiene rules for food of animal origin (853/2004/EC).

3.4.2 Sticking

Citrate: Citrate/citric acid has widespread use in the food industry and is used to prevent coagulation of the blood collected from the slaughter line.

After stunning, a shackle is placed around the foot of the pig and the entire animal is hoisted to an upside down position. The carotid arteries are then cut and the animal bleeds without regaining consciousness.

Sticking is carried out in the middle of the throat (behind the larynx), so that both the carotid arteries and jugular veins are cut. The cut itself must be around 4 cm in length in order to allow unobstructed bleeding. During sticking, it is important to ensure that contamination with surface bacteria does not occur as a result of damage to the gullet.

If the blood is to be used in the human food chain, the animals are specially tattooed with a number corresponding to the batch from which the blood is collected. This occurs immediately after shackling.

The sticking is carried out with a knife around 20 cm in length or a hollow knife. The hollow knife is used if the blood is to be used in the human food chain. The knife is connected to a container in which blood from around 25-30 pigs is collected. Following sticking of each

pig, the hollow knife and tubes are replaced by freshly cleaned and disinfected ones from a special carousel. During the bleeding of the animal, citrate is added to avoid coagulation.

3.4.3 Bleeding and blood collection

Blood, approved for use in the human food chain

Both the containers and collection equipment are disinfected with steam or hot water (82 °C) before use.

Some of the approved blood is used in the production of meat products. The rest is centrifuged and separated into plasma (around 60%) and haemoglobin. The plasma is frozen in a fine-ice machine at -35 °C. A roller is used to remove the plasma in flakes, which are then packed and stored in a freezer. The haemoglobin is cooled to 2 °C and subsequently frozen in plates.

Blood plasma is sold as a supplement for food products. The haemoglobin (red) is used for other purposes such as feed for mink animals.

Non-approved blood

Blood, from approved pigs (visual inspection), that has not been approved for use in the human food chain is collected in containers and used in e.g. animal feed products.

3.4.4 Control

Veterinary inspectors check the CO₂ facility every day (always at the start of production) to ensure that sticking of the pigs is correctly performed. In addition, the daily check of the stunning facility and sticking is also part of the company self-audit procedures.

Each batch of blood for the human food chain is approved by the Danish Veterinary Service. Only when all the animals from a particular batch have been approved may the blood taken from these animals

be formally approved. In all other cases, the whole batch is discarded or used in animal feed production.

The whole process is subject to continuous bacteriological control.

3.4.5 Summary

Correct sticking ensures that the animals are killed quickly and around 50% of the animals' blood is drained through the cut made. Correct sticking also contributes to improved keeping quality, which can be impaired as a result of blood flowing from meat surfaces and fat at later stages of production.

Proper identification of matching carcasses and blood ensures that only blood from approved carcasses is used in products for the human food chain.

3.5 Carcase treatment

The treatment of carcase includes scalding, dehairing, singeing, scraping and cleaning, which is known as the 'unclean' section of the slaughter process.

3.5.1 Legislation and industry agreements

The EU regulations laying down specific hygiene rules for food of animal origin (853/2004/EC) state that all pigs must either be skinned or dehaired immediately after sticking.

In addition, Danish co-operative slaughterhouses carry out surface treatment based on Danish Guidelines for Good Manufacturing Practice in respect of scalding, dehairing, singeing, scraping and cleaning of pigs.

3.5.2 Processes

As the Danish industry sells a number of products with rind on, it is important that the surface of the carcase is properly cleaned and dehaired.

Scalding

After bleeding, the carcasses are transported to a scalding tank.

The scalding must allow the hairs to be removed at their roots. For this purpose, automatic scalding tanks are used which ensure that all carcasses are subjected to the same maximum scalding temperature at around 61 °C for 6 minutes. To obtain a uniform process, the carcasses must be wholly immersed in the scalding water, which is continuously circulated.

This process loosens the epidermis so it can be easily removed. Scalding also loosens the hooves, as well as cleansing the carcasses of dirt and bacteria.

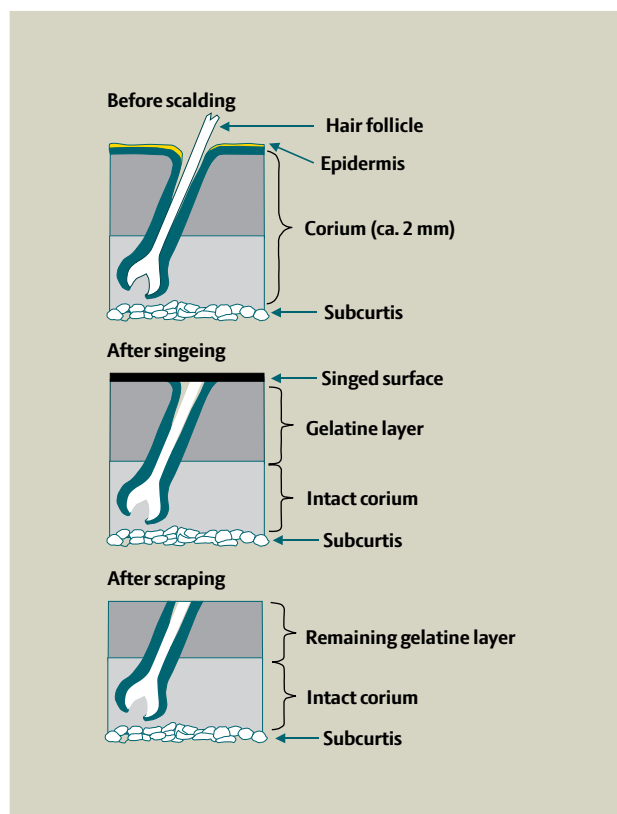


Figure 8: Skin treatment

Dehairing

The shackles are automatically removed from the carcase before it proceeds to the dehairing equipment.

During the dehairing process, the epidermis is removed and hairs are also removed at their roots. This is carried out by pulling the carcase through various revolving metal brushes, which in combination with cold water removes all hairs from its surface.



After dehairing, the carcass is hung on a numbered gambrel, which enables its automatic identification during the whole process until cutting.

Hanging using a gambrel

After dehairing, a gambrel, marked with a number which automatically identifies the carcass through the entire slaughter process, is inserted under the Achilles tendons and the carcass is then hoisted on to an overhead conveyor.

In some slaughterhouses, the lean meat percentage is then measured by means of ultrasonics (Autofom) at this stage in the slaughter process. Otherwise grading takes place as described in section 3.10.



Typically, singeing of the carcass takes place in a furnace at 1000 °C for 6 seconds, thus eliminating bacteria, the remains of bristles and other dirt and preparing the surface of the rind for scraping.

Singeing

The next stage typically brings the carcass via the overhead conveyor to a singeing furnace at 1000 °C for 6 seconds. During singeing, the remaining surface water of the carcass and the water content in the skin evaporates. The heat draws the skin taut due to the denaturing of the collagen fibres in the epidermis, which are transformed into gelatine. The layer of gelatine is softened by the application of water (Figure 8, in the middle) allowing it to be scraped off without damaging the underlying layers.

It has been found that singeing removes bacteria, remains of bristles and dirt far more effectively than other methods such as flaming.

Scraping and brushing

After singeing the carcass travels to an automatic measuring station where the position of the lower edge of the forelegs is determined in order to set the scraping and brushing equipment. Three types of processes are used:

- Black coloured scrapers mounted horizontally and vertically to carry out the initial work
- Specially designed brushes to clean the less accessible places
- Movable brushes on a rotating shaft, whose downward movement is dictated by the carcass weight.

During scraping and brushing, the carcass is sprayed with water. The water both cools and cleans the rind and softens some of the gelatine layer (c. 1/2 mm), which is then removed by the scraping. The hooves are removed by a specially designed tool.

A final drying process to remove the remaining surface water completes the rind treatment.

Having gone through the complementary processes of singeing, scraping and brushing, the carcass is then transferred to the next 'clean' stage of production.

3.5.3 Monitoring and control

The appearance and cleanness of the carcasses is checked during re-inspection after grading, and by the veterinary inspector as part of the meat safety control measures, to ensure that the carcass has been properly cleaned.

3.5.4 Summary

Effective rind treatment produces an unblemished surface of the carcass, free from hair and dirt and of a high bacteriological standard. The surface bacterial count after rind treatment is normally less than 10^4 .

This treatment used ensures the following:

- Taut and firm surface which is easy to cut (see Figure 8)
- Removal of bacteria and other potential sources of contamination, such as insects
- Undamaged surface free from hairs and other blemishes.

3.6 Removal of intestines and organs

This stage comprises the opening of the carcass, cutting of the fat end and removal of intestines and organs (known as the 'clean' stage of the process).



To avoid cross-contamination during the removal of plucks and other organs, the slaughterhouses have introduced a 'two-knife' system, where all cutting tools are decontaminated in hot water (at 82 °C) between each treatment.

3.6.1 Legislation and industry agreements

The removal of intestines and organs is carried out in accordance with the EU regulations laying down specific hygiene rules for food of animal origin (853/2004/EC). The regulation specifies that the removal of organs must be completed as soon as possible after stunning. Organs and intestines must remain in contact with the carcass until the veterinary inspector has completed his check. If the organs and intestines are separated from the carcass, these must be identified with a number or other identification to enable a link between them and the carcass. No contact is allowed between carcasses or organs approved for human consumption and unexamined carcasses or organs.

In addition, the industry requires that a plastic bag (or similar apparatus) is used during removal of the fat end.

3.6.2 Removal of intestines and organs

The removal of intestines and organs from the carcass is critical to the hygiene standard of the whole process.

During the opening of the carcass and removal of the organs, there is a great risk of bacterial spread if any perforation occurs. Also, the area between the hindquarters and the breast may have been contaminated during the rind treatment and it is crucial for slaughter hygiene that spreading of bacteria does not occur during these processes. All processes are performed by specially trained personnel. To avoid cross-contamination, all cutting tools are decontaminated in hot water (82 °C) between treatment of individual carcasses.

Carcass opening

The carcass is opened by opening the belly without cutting through the abdominal wall. Legs are then separated without damaging the musculature. The abdominal wall is then cut through, after which bladder and sexual organs are removed.



A process for the automatic removal of organs has been developed. The plucks and intestines are removed together by a machine and are then separated manually, away from the carcass itself. This procedure removes a burdensome task for the operator and is more hygienic than previous methods. The new equipment is not yet installed in all slaughterhouses.

The carcass opening process is now fully automated at several abattoirs. Besides relieving operators of heavy lifting, the risk of contamination is significantly reduced.

Cutting the fat end

With a rectum loosener, the fat end is cut loose, secured by means of vacuum and pulled out. To avoid contamination, the operator wears a plastic bag around his free hand. The bag is pulled over the fat end

after which the bag and fat end are pushed between the legs so that the fat end is separated from the carcass and no faecal contamination occurs.

Between each operation, the rectum loosener is decontaminated in hot water (82 °C).

The slaughterhouses can also use alternative methods provided that these can be demonstrated to be as effective in preventing faecal contamination.

Removal of intestines

After loosening the fat end, the separation of the legs is completed. The stomach is tipped out of the abdominal cavity and the gullet is cut through 2 cm from the stomach in order to avoid spillage of the stomach contents. The stomach, intestines, pancreas and spleen are removed as a single unit and placed on a tray which follows the carcass so that both may be examined simultaneously by the veterinary inspector.

Removal of organs

The thoracic cavity is split open by cutting through the fat and meat over the breastbone, after which the carcass is opened with a saw cutting straight down the breast. After each operation, the knife and saw are cleaned and disinfected in hot water (82 °C).

Flare fat and diaphragm are loosened from the abdominal and thoracic walls before the gall bladder is cut off and the tenderloins loosened.

In the Danish process, the pluck consists of tongue, throat, gullet, trachea, heart, lungs, diaphragm, kidneys and liver. The organs are connected by membranes and are from the thoracic cavity. The

organs are cut loose so that they only hang from the muscles of the tongue bone. The tonsils are removed undamaged from the palate. The tongue is then cut loose from the jaw and the pluckset is placed on a hook whose identification mark is attached to the carcass, so there is a clearly identified link between the carcass and its organs.

3.6.3 Control

The veterinary inspectors supervise the removal of intestines and organs to ensure that this process is carried out hygienically. Procedures to minimise the risk of bacterial spread during the removal of intestines and organs are incorporated in the self-audit programme of the slaughterhouse. The self-audit programme is carried out on-line, with visual control and registration of any faecal contamination.

If the stomach or intestines are damaged, these are left in the carcass. The carcass is then turned a 180° to ensure that splitting of the carcass does not take place before examination by the veterinary inspector.

Monitoring for presence of Salmonella in fresh meat (c. 1.300 samples per month from carcasses) provides a valuable additional check that good hygiene procedures are being followed. On a daily basis, five carcasses are examined at each abattoir. The five samples are pooled into a single sample for analysis to give a daily result for each abattoir.

The veterinary inspectors examine the carcass, the intestines, the pluck and the sexual organs of all slaughtered pigs, in accordance with the EU regulations laying down specific rules for the organisation of official controls on products of animal origin intended for human consumption (854/2004/EC). The other aspect of their work includes laboratory analyses to test for presence of residues. As part of the companies' self-audit programme, testing for presence of antibiotic residues is also carried out. Any issues arising from the veterinary

inspection are communicated to the supplying producer. The link between carcass, intestines and the pluck may only be broken after formal approval by the veterinary inspector.

Additional checks are made by daily random sampling and all cutting faults are registered and scored by a weighting system. If the acceptable limit for cutting faults is exceeded, a fuller examination is carried out and the results taken up with the employee concerned.

3.6.4 Summary

The procedure for the removal of intestines and organs and the close follow-up procedures aim to ensure a high level of hygiene with minimal risk of contamination. The low levels of Salmonella recorded demonstrate this.

The feedback from the veterinarians to individual producers on the health condition of the pigs delivered allows a rapid response to any disease symptoms in the herd.

3.7 Carcase splitting

This stage comprises the preliminary incision, loosening and sawing of the back of the carcase.

3.7.1 Legislation and industry agreements

The splitting of the carcase by sawing through the vertebrae is carried out in compliance with the EU regulations laying down specific hygiene rules for food of animal origin (853/2004/EC).

3.7.2 Methods

All Danish co-operative slaughterhouses use an automated carcase splitting process. The long muscle of the back is loosened from the vertebral area before the carcase is split into two sides.

Preliminary incision and loosening

A deep cut is made through the cartilage in the vertebral area from the tail to the top of the neck along the dorsal fin. After this, the so-called 'flat bones' are loosened on both sides. The tools must be disinfected in hot water (82 °C) between each carcase.

Splitting

An automatic saw splits the vertebrae from tail to snout. Before the carcase is split, the length of the pig is measured so that the sawing can be carried out without damaging the muscle. Intact muscles are important to ensure good meat quality and keepability. After each operation, the saw is automatically sterilised in hot water (82 °C).

3.7.3 Control

The veterinary inspectors carry out an examination of the carcase, the spinal cord and head. The slaughterhouse assesses the quality of the process by systematically registering any faults. This can be, for instance, through a scoring system where serious faults result in more points than minor faults. If threshold values are exceeded, corrective

actions are taken immediately, which may include additional cutting, adjustment of equipment or retraining of employees.

3.7.4 Summary

The process of splitting carcasses aims to leave the meat and membranes undamaged. If the processes are carried out incorrectly, this will have major implications for the microbiological standard and quality of the meat.

3.8 Post slaughter inspection (official veterinary inspection)



The veterinary inspector examines each carcass for evidence of disease, injuries, odour, lack of uniformity or damage, which may render the carcass unfit for human consumption. On the slaughter line the veterinary inspection also involves making incisions into the carcass in relevant areas.

This stage comprises inspection of carcasses carried out by the Danish Veterinary Service in accordance with the EU regulations laying down specific inspection rules for products of animal origin (854/2004/EC).

3.8.1 Legislation and industry agreements

EU regulations (854/2004/EC) require that all parts of the animal must be examined immediately after slaughter to ensure that the meat is suitable for human consumption. Organs, intestines, head and tongue must be examined together with the carcass. When the veterinary inspector has approved the carcass and these other parts,

they can then be processed separately from the carcass. The same procedure applies to the brain, spinal cord and flare fat.

Meat declared unsuitable for human consumption must not come into contact with any meat approved for the human food chain.

3.8.2 Detailed inspection

The post-slaughter inspection is divided into the following three areas:

- Inspection of carcass and head
- Inspection and palpation of intestines and organs, with incisions into some organs and lymph nodes, where necessary
- Supplementary inspection of specially designated carcasses.

Inspection of the carcass

The veterinary inspector examines the carcass for evidence of disease, injury or any other factors, which may render the carcass unfit for human consumption.

On the slaughter line, the carcass is visually inspected and examined by cutting into relevant areas. If the veterinary inspector concludes that the carcass should be subjected to further examination, it is transferred to a separate meat inspection rail.

Observations by the veterinary inspectors are recorded either electronically by linking to the gambrel number or by a label attached to the carcass, based on a standard coding system. During weighing, the label is removed and the code and remarks are recorded together with the gambrel and producer supply number.

In addition, a sample from the diaphragm is removed from each pig for examination for trichinae. Trichinae have not been found in Danish pork since 1929.



If further examination is required before the carcass or the intestines and organs can be approved for human consumption, it is transferred to a separate inspection rail, where a more detailed examination takes place.

Inspection of intestines and organs

In accordance with EU regulations (854/2004/EC), the veterinary inspectors examine and may cut into organs and lymph nodes, according to procedures laid down by the Danish Veterinary and Food Administration. If pathogenic changes are observed, no cuts are made at this stage, but the carcass and organs are immediately transferred to the separate rail for supplementary meat inspection. This prevents any contamination of other meat.

If the veterinary inspector decides that organs or intestines should be subject to further examination, these are taken with the carcass for laboratory testing.

Supplementary inspection

If additional examination is necessary prior to formal approval of the carcass, intestines and organs, the carcass is transferred to a separate rail for supplementary meat inspection.

Carcasses with intestines damaged during their removal are also re-examined, at which point the organs are removed under increased hygienic conditions. The veterinary inspector then decides whether the carcasses can be approved for human consumption.

When the veterinary inspector has approved the carcass, the pluck set and intestines are taken to a special area of the factory where they are processed.



Observations by the veterinary inspectors are recorded electronically by linking to the gambrel number.

3.8.3 Summary

The Danish Veterinary Service is responsible for examination and approval of all carcasses, intestines and organs to ensure that all Danish pork and pig meat products are suitable for human consumption in compliance with the requirements of EU regulations (854/2004/EC).

The veterinary inspectors also register information on any injury or disease symptoms. These remarks are communicated to the producer together with his payment details. The producer is therefore given early warning of any risk of disease and may then take preventative action before a significant problem develops in the herd.

If further investigation is needed, the carcass and organs are taken aside for closer examination. In this way, the veterinary inspector can carry out a thorough examination of the carcass without any risk of cross-contamination.

3.9 Cleaning

This stage comprises cleaning of the carcase before weighing and grading.

3.9.1 Legislation and industry agreements

The regulation concerning weighing, grading and reporting of market prices for pig, cattle and sheep carcases (Reg. no. 434/2009), implements the Council's order (EU) no. 1234/2007 and the Commission's order (EU) no. 1249/2008.

3.9.2 Removal of brain and spinal cord

Immediately after the veterinary inspection, the spinal cord and brain are removed. The spinal cord is removed with a special tool or with suction apparatus.

3.9.3 Removal of flare fat

During the opening of the carcase, the flare fat is loosened. Before weighing, the flare fat is extracted and remnants are trimmed off.

3.9.4 Control

Danish legislation allows the removal of brain, spinal cord, and flare fat from the carcase before weighing.

The Danish Pig Classification Authority ensures that the brain, spinal cord and flare fat have been correctly removed from the carcase before weighing.

3.9.5 Result

The process ensures that carcases are properly cleaned and prepared for further processing.

3.10 Weighing, grading and Health Marking

This stage comprises weighing, registration of coloured hair follicles, grading for lean meat percentage, marking of the carcass and payment to the pig producer.

3.10.1 Legislation and industry agreements

The Danish Pig Classification Authority: controls the weighing, grading and payment for pigs. All slaughterhouses slaughtering more than 200 pigs per week are supervised by the authority, in accordance with the Ministry of Food, Agriculture and Fisheries' requirements (Regulation No. 434/2009)

The weighing and grading of slaughter pigs is carried out in accordance with relevant EU regulations. The lean meat percentage is determined by objective measurement of the thickness of fat and meat, using measuring equipment approved by the EU Commission.

The Health Marking of pigs is performed in accordance with the EU regulations laying down specific rules for the organisation of official controls on products of animal origin intended for human consumption (854/2004/EC).

The Danish Pig Classification Authority is responsible for the control of the weighing, grading and payment to producers, on behalf of the Ministry of Food, Agriculture and Fisheries.

Only operators that have been approved by the authority may weigh and grade the carcasses. The procedures for supervising the operation of the Classification Centres were drawn up in co-operation with the Danish Meat Research Institute. These procedures also incorporate

the Danish pig industry's guidelines for weighing, grading and payment for sows.

3.10.2 Weighing

The slaughter weight is defined as the weight of the warm carcass, including head but without intestines, tongue and organs. The weight is recorded at the slaughterhouse no later than 45 minutes after sticking. Some abattoirs have dispensation to leave the organs in the carcass before weighing. Corrections are then made prior to weighing.

On weighing the carcass, the supplier number is linked to the number of the gambrel, with any observations by the veterinary inspector, as well as slaughter number (no. of slaughtered pig on that specific day). In addition, the date, the time and any pigs with coloured hair follicles are registered. Pigs with coloured hair follicles account for less than 2% of the total number of pigs slaughtered and are not used for rind-on products. The proportion is kept at the lowest possible level through a financial deduction.

3.10.3 Grading

In Denmark, the classification of pigs serves the following two purposes:

- Fair payment to the producer for the pig delivered
- Grading of different carcasses.

The lean meat percentage in pigs is automatically measured at the Classification Centre after weighing or after dehairing, if Autofom equipment is used.

Grading at the Classification Centre (CC)

The Classification Centre is constructed as an oval system where the carcass is automatically suspended on a fixture that leads the carcass



Autofom calculates the meat and fat content of the carcass, based on ultrasonic measurements. The measurements are performed by 16 transducers mounted on a channel over which the carcass passes once it has been transferred to the gambrel.

through various stations. Based on measurement of length and the height of the foreleg and pubis bone, the CC's probes are adjusted so measurement can be taken at specific anatomical positions. The thickness of fat and meat is then measured by optical probes.

These measurements are made by a total of seven probes as follows:

- Leg: two probes for fat thickness
- Loin: three probes for fat thickness and meat thickness
- Fore-end: two probes for fat thickness.

Using neural networks, the following lean meat percentages are calculated:

- Overall lean meat percentage in the carcass
- Lean meat percentage in leg
- Lean meat percentage in the middle
- Lean meat percentage in the fore-end.

These measurements and calculations are used as grading criteria for carcasses and cuts to ensure the best possible utilisation of meat in the carcass.

The automatic grading system has the following advantages over other manual systems:

- High capacity (420 carcasses per hour)
- More precise and uniform measurements
- No operator bias
- More accurate results for different pig breeds
- More accurate selection linked to weight and lean meat percentage.

Grading with the Autofom system

Autofom calculates the meat and fat content of the carcass based on ultrasonic measurements. The measurements are performed by 16 transducers mounted on a channel over which the carcass passes immediately after it has been transferred to a gambrel (See Section 3.5.2).

The measurement precision is on a par with the Classification Centre (CC) but Autofom has other benefits:

- High operational reliability
- Minimal wear and tear (no movable parts)
- Very high capacity (over 1,300 carcasses per hour).



Following a satisfactory inspection, the carcass is branded automatically with an EC Health Mark, including the relevant grade and sub-grade. In addition to the special oval EC Health Mark, a coded date-mark is applied to the carcass, which is used in the quality control system, for example, to establish product shelf-life.

3.10.4 Marking

Before the carcass leaves the Classification Centre, the carcass is automatically stamped with an EC Health Mark, a trade grading mark and sub-grade mark. If the Autofom is used, the carcass is branded at an independent marking station.

One EC Health Mark is applied to each carcass. If the carcass is cut into half carcasses or smaller cuts, each cut must be branded with the EC Health Mark.

In addition to the oval EC Health Mark, a coded week and day mark is applied to the carcass, which is used in the quality control system of the company to establish product durability.

Since the EU hygiene orders (852/2004, 853/2004 and 854/2004) came into operation, the EC stamp on the Health Mark has been gradually replaced by EU or another abbreviation for the Community. However, up to 31st December 2009, the old stamp may still be used.

3.10.5 Salmonella screening

The slaughterhouse collects random samples from all herds delivering over 200 pigs per year to carry out tests for presence of Salmonella antibodies. The number of random samples is determined by the number of pigs delivered. Carcasses to be tested are automatically selected during weighing. After grading and marking, a meat sample of 10 g is collected and placed in a special container with a label that clearly identifies the supplier of the carcass. The sample is frozen down and when thawing out the meat juice is analysed for presence of Salmonella antibodies.

3.10.6 Payment

The payment is made to the farmer on the basis of weight and lean meat percentage. The highest basic price is obtained from slaughter pigs at 70.0-85.9 kilos slaughter weight. A lean meat percentage of 61% will add DKK 0.1 for each percentage point up to 65%. A lean meat percentage between 57.0-60.9% will result in a deduction of DKK 0.1 for each percentage point below 61%. In 2008, the average slaughter weight was 81.6 kg and the average lean meat percentage was 60.4%.

When receiving payment, the producer also receives data on weight and lean meat percentage for each pig delivered, information regarding any presence of coloured hair follicles and any observations by the veterinary inspector. The results of the Salmonella testing are also conveyed to the producer in order that both he/she and the pig adviser may be kept aware of the Salmonella status of the herd (See Section 5.2.7).

3.10.7 Control

The weighing and grading of carcasses is carried out by personnel specially trained by the Danish Pig Classification Authority.

The companies must follow the operational control procedures for the Classification Centre and Autofom laid down by the authorities. These are monitored on a continuous basis, with a view to rectifying faults that occur. In a situation where the equipment breaks down, the approved operators are able to classify the carcasses manually.

The Danish Pig Classification Authority supervises the weighing, grading and payment to the pig producers through random control procedures and also analyse the classification data on a weekly basis. Any faults in the Classification Centre, Autofom or manual equipment are rectified as soon as possible.

3.10.8 Summary

Classification data is used to identify which carcasses and cuts are suitable for particular products. This enables the slaughterhouses to meet detailed customer specifications regarding size, meat content and so on.

Payment is made to the producer on the basis of weight and lean meat percentage. The system encourages a more uniform weight and, therefore, size of cuts.

3.11 Chilling

This stage comprises the chilling and equalisation of carcasses before cutting.

3.11.1 Legislation and industry agreements

According to EU regulations laying down specific hygiene rules for food of animal origin (853/2004/EC), the inner temperature of a carcass must be no more than 7 °C after equalisation.

3.11.2 Chilling and equalisation

Carcasses are normally chilled in specially developed tunnels. For environmental reasons, ammonia is used instead of CFC gases as refrigerants.

Process time, air temperature and air rate of the chilling process all affect meat quality. The beginning of the chilling process is of particular importance for the meat tenderness. The chilling aims to reduce the inner temperature to a maximum 5 °C during the first 26 minutes. The chilling takes place at -20 °C to -22 °C with average airflow of 3



From the chilling tunnel the carcass is then moved to an equalisation chamber (3 – 5 °C). The temperature difference between the centre and the surface of the carcass is equalised until the overall temperature falls below 7 °C. Carcasses are usually chilled and equalised within 20 hours following slaughter.

m/s maximum. The method ensures an effective chill without the risk of cold shortening, as laid down in the industry meat quality guidelines.

3.11.3 Equalisation

From the chilling tunnel, the carcasses are transported to an equalisation room (3-5 °C). The temperature difference between the centre and the surface of the carcass is equalised so that the temperature in the whole carcass is less than 7 °C. Carcasses are usually chilled and equalised within 20 hours after slaughter.

The air current is distributed with permeable air socks, so a more effective process is obtained. Also, condensation on ceiling, pipes and walls is avoided and a potential source of contamination is eliminated.

When transferred to the equalisation room, the carcasses are automatically sorted on the basis of data provided by the Classification Centre. The carcasses are held in the equalisation room until cutting.

3.11.4 Control

Information on time and temperature conditions is recorded during the chilling process. The temperature in all chilling and boning rooms is measured and automatically registered every half hour. In case of a rise of temperature, an alarm is sounded in order that the necessary corrective actions may be taken immediately.

Product temperature is checked by the slaughterhouse at least once a day. The veterinary inspectors have access to the temperature records of the company.

3.11.5 Summary

The chilling process employs a rapid cooling of carcasses without impairing the quality of the meat through cold shortening. Rapid cooling also reduces the rate of the pH decrease and thus minimises the risk

of PSE, as well as limiting the risk of microbial growth (see 5.3.1). The system also limits the possibility of contamination by condensation in the surrounding environment.

4 Cutting and boning

Chapter 4 covers the cutting and boning of carcasses. These two processes require highly skilled personnel producing several hundred standard cuts. It focuses on sorting and primary cutting as this serves as basis for specialised products. Finally, packing, wrapping and, where appropriate, freezing of the finished products is also described.



4.1 System



The companies are responsible for the quality of the meat cutting process. It is the responsibility of each manager to ensure that all products meet specified quality standards and remain free from foreign bodies.

4.1.1 Cutting rooms

The cutting and boning of carcasses is performed either at the abattoir where the pigs have been slaughtered or at a separate cutting plant.

The further processing of carcasses usually consists of the following procedures:

- Sorting
- Primal cutting
- Boning
- Packing and labelling
- Deep freezing, cooling and dispatch.

In contrast to the slaughter process, which is highly mechanical, these processes are less uniform and still largely based on manual systems. This factor has considerable bearing on the factory design, the organisation of the production floor, quality control and especially the skills of the personnel involved.

With support from the Danish Meat Research Institute and the Danish Meat Trade College, all Danish slaughterhouses have a cutting and boning operation based on highly skilled operators, who cut and trim Danish pork in modern hygienic facilities to high standards.

4.1.2 Foreign bodies

Any matter, which does not form part of the product specification, is regarded as a foreign body. This may be cartilage, sinew or bone remnants, as well as tags or other items accidentally entering the meat.

The risk of foreign bodies entering the production chain can be minimised by preventative measures, veterinary inspections and system testing. All production personnel must wear special clothing provided

by the management and may not wear watches or jewellery or similar items.

Quality requirements are specified for all working procedures and all personnel receive full training. For example, all cuts of meat must be free from cartilage and bone fragments. The factory has all necessary tools at its disposal and is responsible for their maintenance, as defective equipment may present a risk of contamination.

The company is responsible for overall quality control of the meat cutting process. It is the responsibility of each manager to ensure that products are of the specified quality standard and free from foreign bodies. Additional control and testing of the systems are described below (section 5.4).

4.1.3 Food safety

Primal cutting and deboning must conform to the requirements for the hygiene of foodstuffs (852/2004/EU) and the specific hygiene rules for food of animal origin (853/2004/EC) to ensure an unbroken cool chain as well as overall hygiene levels. The company self-audit programme requires constant temperature recording in the chill rooms. Working procedures are also organised to ensure that carcasses and cuts only leave the chillers for further processing.

4.2 Cutting

This stage involves the cutting of the half carcasses into primal cuts - shoulders, middles and legs.

4.2.1 Legislation and industry agreements

The EU regulations laying down specific hygiene rules for food of animal origin (853/2004/EC) specify temperature requirements for carcasses before delivery to a cutting plant or being sorted for further cutting and boning on site. Before cutting, the carcasses must have an inner temperature of less than 7 °C, unless boning at a higher temperature is permitted in accordance with EU regulations (853/2004/EC).

In addition to this, each company has detailed product specifications outlining the requirements for product quality and processing (including the necessary hygiene requirements). Product specifications are often developed in collaboration with customers.

4.2.2 Sorting

Both the carcasses and the major cuts have been measured on the slaughter line for lean meat percentage and fat depth (See Section 3.10.3). Based on this data, the carcasses are automatically sorted in the equalization rooms. Carcasses with similar quality properties are collected on the same rail. This way of grading the pigs ensures that particular raw materials are used for the most suitable products.

Based on the data collected, production lists are drawn up for cutting and boning on the following day.

During the slaughter process (see Section 3), veterinary inspectors examine each carcass. The carcasses that have been taken aside for further examination (e.g. laboratory analysis) are specially marked and placed in special sections in the chiller. These will only be released when the final laboratory results are available, which authorise use of the meat for further processing.

4.2.3 Primal cutting

Primal cutting usually means dividing the carcass into main cuts: leg, loin, belly and shoulder. The cuts may be boned and processed according to customer specifications.

Primal cutting involves the following processes:

- Removal and trimming of the tenderloin
- Laying down the carcass and removal of head and hind toes at the joint
- Splitting the carcass into three parts
- Splitting of the middle from the belly.

All cutting must be precise and clearly defined. Laying down the carcasses on conveyor belts and use of automated saws considerably enhances the cutting process as well as easing the workload for operators.

Removal and trimming of the tenderloin

When the carcass is originally opened, the tenderloin is loosened (See Section 3.6). The tenderloin is then removed from the abdominal cavity immediately after the carcass leaves the equalisation room. It is then trimmed and vacuum-packed, and dispatched for final packaging, cooling or freezing.

Removal of head and hind toes

The two halves of the head are cut off at the neck joint without the neck jowl. The head is transported directly to boning after which bones and waste are transferred directly to a container and dispatched for rendering.



The two half carcasses are automatically lowered onto a conveyor belt, after which the hind toes are sawn off.



Each half carcass is then split in three parts. Laser light or phototechnology is used to ensure its correct positioning, before being divided into the three primal cuts: the fore-end, the middle and the leg.

The two half carcasses are automatically lowered onto a conveyor belt. The hind toes are sawn off at the highest point on the hock right through the heel bone. A correctly sawn off hind toe leaves a “star” on the cutting edge.

Splitting the carcass

The half carcass is split in three parts by a fully or partly automated process. To achieve maximum precision, laser light is used to ensure correct placing of the carcass prior to sawing and cutting into primals, the fore-end, middle and leg. Circular saws are used which are capable of cutting through both meat and bone.

The shoulder is removed with a vertical cut perpendicular to the longitudinal axis of the far side of the fore knuckle of the pig (around three joints from the breast bone). The neck jowl is removed according to specification and customer demands, trimmed and sent for further processing and packing. The shoulder is sent on either as

a whole or is further split into a boneless collar and shoulder. The boneless collar is cut off with or without the neck bone depending on the final product. The shoulder with hock is sent on for boning and processing. Alternatively, the complete fore-end may be sent for boning.

The leg is removed with a vertical cut perpendicular to the side where the tailbone and the aitchbone join. The tailbone, groin meat and groin fat are cut off (round cut) and the leg is then dispatched.

From the middle, the rib-top is sawn off by sawing through the ribs.

Splitting of the middle

For certain products, the middle is split into loin and belly by a vertical cut along the line of the back so that the first rib (measured from the fore-end) is 4 cm long and the last rib is 7.5 cm long measured from the inner side of the head of the ribs. None of these measures may vary more than 0.5 cm.

4.2.4 Dispatch

Cuts for dispatch are normally transported on rails and hung on 'Christmas trees'. They may be shipped in chilled containers as fresh products for export but usually they are sent for boning (see section 4.3).

On the day of dispatch, the cuts must be no more than four days old, calculated from the time of slaughter. At dispatch, the temperature must not exceed 7 °C. The products must not be exposed to any temperature increases, which may cause condensation on the meat. The temperature at dispatch is normally less than 5 °C.

4.2.5 Control

Carcases are inspected visually before cutting. If defects are observed, the carcass is taken aside for further treatment. Control is usually



Cuts for further delivery are hung on a 'Christmas tree'. The hanging rails can be adjusted vertically to ensure that the cuts are hung properly.

carried out by experienced personnel who have been given special training.

The temperature in the chillers is continuously monitored as part of the companies' self-audit programme. An alarm system is activated, if the temperature exceeds 7 °C in the chillers and 12 °C in the production area. The chillers are specially cleaned to ensure optimum hygienic conditions.



These are then moved into cold storage or directly onto transport vehicles. The temperature must not exceed 7 °C.

The manager is responsible for ensuring each cut meets detailed specifications. In addition, the companies' quality controller carries out random tests to ensure that the work is carried out to specification.

A specialist company is usually appointed to take charge of the cleaning and, as part of its self-audit procedure, is responsible for the daily control before the production starts. In addition, the company itself re-checks the cleaning before production starts, which is documented. The Danish Veterinary Service makes random checks of cleaning, hygiene levels and other procedures.

4.2.6 Summary

Sorting of the carcasses according to weight and lean meat percentage ensures that they are used for the most suitable purpose. Following that, detailed product specifications combined with sophisticated

cutting equipment delivers a product which is closely aligned to customer demands.

Automated sorting and cutting also provide a rapid process flow, allowing the meat to be rapidly shipped on to chillers for further processing.

Good temperature control and a carefully controlled cleaning regime inhibit bacteria growth and maintain a high hygienic standard.

4.3 Boning

Much of the pig meat exported from Denmark is in the form of boneless cuts. These may either be standard cuts or cuts tailor-made to customer specifications and include legs, shoulders, loins and bellies. The uniformity and consistency of Danish pig meat is recognised in many markets. It is linked partly to the basic properties of the raw materials, and partly to the high standards of butchery carried out in modern hygienic facilities.

4.3.1 Legislation and industry agreements

The requirements in the EU regulations on the hygiene of foodstuffs (852/2004/EC) and the hygiene rules for food of animal origin (853/2004/EC) are observed by the Danish slaughterhouse companies.

4.3.2 Boning process

After the initial cutting process, the products are then moved to the boning section, sometimes via a buffer chiller stock.

The production is organised to ensure that all cuts are boned and finished in strict chronological order.

In the boning section, cuts are weighed and then placed before each operator. Each product is given a detailed specification with an accompanying work description in line with customer requirements. Product specifications and working descriptions are drawn up as part of internal company rules, specifying all quality aspects of the required boning process.

Where quality deviations are identified or if a product has fallen on the floor, it must be submitted for re-inspection, while the workstation and tools must be cleaned and disinfected.

Once the cuts are trimmed to product specification, they are either placed in boxes or loaded onto a 'Christmas tree' and immediately



Detailed specifications exist for all cutting and de-boning procedures. The specifications ensure uniformity and may be adjusted in line with customer demand.

moved on to the next stage of production or shipment, thus avoiding any unnecessary rise in temperature.

In addition to the requirements of the EU regulations on the hygiene of foodstuffs (852/2004/EC), each company has its own procedures for cleaning of workstations. Equipment and tools are replaced



At the re-inspection procedure, any segregated or discarded cuts are examined and subsequently returned or sent on for alternative types of production. All trimmings must go for rendering. Only experienced personnel may carry out the task of re-inspection.

several times daily, according to requirements, in order, to avoid contamination between particular production batches.

4.3.3 Re-inspection

At re-inspection, any segregated or discarded cuts are examined and subsequently returned or sent on for alternative types of production.

All trimmings go for rendering or further processing for animal feed. Only experienced personnel are used for the task of re-inspection.

The control, which takes place at the end of the conveyor line in the boning room, may require further trimming to meet the requirements of the product specification or removal of any bone fragments still present.

After boning and trimming, the meat is weighed and stored in a buffer chiller, where it is sorted either for packing or further processing.

4.3.4 Control

The temperature in the chiller is continuously monitored as part of the companies' self-audit programme. An alarm system is activated if the temperature exceeds 7 °C in the chill room or 12 °C in the production areas.

In each section, the manager ensures that products meet the agreed specification. The control frequency and number of butchery faults allowed before corrective actions are taken are laid down in the companies' quality control system. By comparing the weight of the cuts before and after boning, management is able to check whether an individual operator has produced too much waste and that the batch meets the agreed specification.

If it is found that a particular fault cannot be immediately rectified by the operator in question, the product is used for alternative production where the quality demand is met. If an individual operator has committed an unacceptable number of faults, a special training programme is initiated to retrain him to the required standard.

The companies also have a special quality control department carrying out spot checks in the cutting and boning area.

A specialist company is usually appointed to take charge of the cleaning and, as part of the self-audit procedure, is responsible for the daily control before the production starts. In addition, the company itself re-checks the cleaning procedures daily before production starts, which is documented. The Danish Veterinary Service makes random checks of cleaning, hygiene levels and other procedures.

4.3.5 Summary

By careful temperature control and use of buffer chillers, bacteriological growth is minimised.

Adherence to detailed product specifications has been a major factor contributing to the uniform quality standards achieved by Danish co-operative slaughterhouses.

4.4 Packing and marking

This stage comprises requirements for packaging, the types of packing material used and the marking of fresh meat products.

4.4.1 Legislation and industry agreements

Packaging requirements are covered by regulations from the Danish Food and Veterinary Administration (Regulation No. 167/2009), which implement the EU Directives in the area. The regulation comes under the provisions of foodstuffs legislation (Act No. 526/ 2005).

According to the Act on Foodstuffs and EU regulations on the hygiene of foodstuffs (852/2004/EC), packaging must be sufficiently robust to provide effective protection of meat during transport and handling,

and must protect against contamination by any harmful substances. The packaging used must also ensure that the sensory properties of the meat are maintained.

4.4.2 Packing

Fresh meat from Denmark is dispatched either unpackaged in a refrigeration truck or in a minimum of two layers of packaging. The inner layer must be an impermeable plastic wrapping, which prevents contamination of the meat and an outer layer of robust packaging material, which protects the meat against physical damage and eases its storage. The outer packaging material may either be cardboard or recyclable plastic boxes.



Finished cuts are immediately wrapped with film after which they are placed in cardboard packing, either by weight or number depending on customer requirement.

Bulk packing

For bulk packing of meat, a plastic film or bag is placed underneath the meat tray, which then automatically tips the meat down into the packaging. The product is then sent for packing in cardboard boxes in an adjoining room.

Recyclable plastic boxes are now commonly used. These boxes are cleaned and disinfected before they arrive at the plant. Each box is lined with a plastic bag before the cuts are placed in it. The plastic bag is then closed and additional plastic is wrapped around the opening of the box. The boxes are stacked on pallets, which are covered with plastic film before dispatch.

Individual packing

Individual cuts are automatically wrapped with film, after which they are placed in cardboard packing, either by weight or number depending on customer requirement.

In addition to hygienic considerations, the strength and stability of packaging material is crucial and strengthened cardboard is therefore used.

4.4.3 Identification

After packing, the boxes or plastic crates are weighed and labelled with the following information:

- Production plant number
- Company name and address
- Product type contained in the carton
- Origin
- Date of packaging and ID-number
- Storage instructions. Storage temperature
- Bar code



All cartons are labelled with information about the production plant, the date of packing and storage instructions.

- Animal species
- Product No.
- Code No. for product handling information (the meat is fresh)
- Other code information for other treatment of the product
- Net weight stated in kg
- Identification mark, oval with country code, the company's authorisation number and EC mark or other abbreviations similar to the Health Mark.

Labelling must comply with the EU regulations laying down specific hygiene rules for food of animal origin (853/2004/EC), the foodstuffs regulation (178/2002/EU) and the labelling regulation (Regulation No. 1308/2005).

4.4.4 Control

The Danish Veterinary Service carries out random checks to ensure that individual consignments meet product specification.

4.4.5 Summary

By labelling the meat, the company ensures that the requirements specified in the EU hygiene and food regulations (178/2002/EC) are observed and that the meat can be traced back to the company (See Section 5.5).

By use of different types of packaging and development of new packaging formats, the industry endeavours to meet its customer demands, especially regarding the use of recyclable materials.

4.5 Freezing down and dispatch



Cartons for freezing are stacked on pallets, at a short interval from one another, to enable rapid and effective freezing down of the meat.

After packing, the fresh meat is either stored in a chiller or frozen down before dispatch.

4.5.1 Freezing Down

If products are to be frozen prior to dispatch, this takes place in a freezing tunnel at a temperature of $-45\text{ }^{\circ}\text{C}$ and a high air speed to reach the required temperature of $-18\text{ }^{\circ}\text{C}$ as rapidly as possible.

If these facilities are not available at a particular plant, then, the products are frozen down at an authorised freezing plant.

Blast freezing tunnels are used, and boxes are automatically stacked on racks. When one rack is full, it is taken through a freezer via a conveyor belt. This process takes about 24 hours, after which the product is frozen down and may be stored in a cold store until dispatch.

In other processes, boxes are stacked on pallets at a distance from each other so that air can circulate between the boxes. The loaded pallets are then driven into the freezer where they are frozen down until they have reached the necessary storage temperature.

In recent years, Danish slaughterhouses and the Danish Meat Research Institute have conducted a number of trials to find the optimum freezing method for fresh meat. The method that yields the best result is rapid freezing at temperatures lower than $-30\text{ }^{\circ}\text{C}$. The air speed must be high so that the surface temperature decreases as rapidly as possible in order to avoid evaporation from the surface. The boxes are also separated so that chilling occurs from both top and bottom of the boxes.

4.5.2 Dispatch

The fresh meat is either stored in a chiller where the temperature is $0\text{-}2\text{ }^{\circ}\text{C}$ or frozen down before dispatch.

Before loading, the vehicle is visually inspected to ensure that the physical condition and hygiene standard is adequate. In addition, it must be demonstrated that the vehicle systems are capable of maintaining the required temperature throughout the period of transport.

After inspection, the consignment is loaded directly on to the vehicle without breaking the cooling chain and then sealed, after which the transport itself can begin.

4.5.3 Control

In the chillers, spot-checks of the temperature of the products are regularly carried out. In addition, the packaging is checked so as to ensure that both product and packaging reach the customer at the required temperature and quality.

4.5.4 Summary

The cooling and freezing processes applied by the industry are continually reviewed to ensure that all the pork and pig meat produced by the co-operative slaughterhouses has an optimal shelf life.

Maintenance of an unbroken cool chain from the original chilling of the carcase until final dispatch or freezing down of the fresh meat minimizes the risk of bacterial growth, extends shelf life and ensures minimal drip loss.

5 Cross-functional controls

Chapter 5 describes the cross-functional controls. Food safety involves the whole production chain in Denmark and this chapter begins with a description of the industry's coordinated approach to guarantee the production of safe meat. The approach is based on HACCP principles, by which hazards are identified and controlled along the production chain. Control of pathogenic, zoonotic bacteria including *Salmonella*, requires detailed review and has been described separately. Factors that influence meat quality are then described and the procedures in place to ensure high quality products at slaughterhouses and cutting plants are shown. Finally, the Danish traceability system, which involves the entire production chain in Denmark is presented.



A number of the control systems cover the entire production chain, from breeding of pigs to the final dispatch of fresh meat. In this Chapter, these so called cross-functional controls are described in more detail to illustrate their broader significance for quality control in the whole production chain of Danish pig meat.

Quality is a crucial factor in the production of Danish pork and in order to guarantee high meat quality, Danish slaughterhouses have implemented product safety controls which ensure that the meat is of uniform quality and fit for human consumption.

The whole Danish pig industry is committed to delivery of safe food. These processes are described in more detail in section 5.1. The control of zoonoses has received major priority in research programmes and is described in Section 5.2.

A number of factors influence the quality of pork. These are covered in Section 5.3, while Section 5.4 outlines quality control measures adopted at Danish abattoirs to maintain meat quality throughout the slaughter, cutting and boning process.

To achieve consistent quality, any faults in the production process must be quickly identified. For that purpose, a system for marking and identification has been implemented which covers the entire production chain from farm to delivery to customers. The system of traceability is described in Section 5.5.

5.1 Food safety

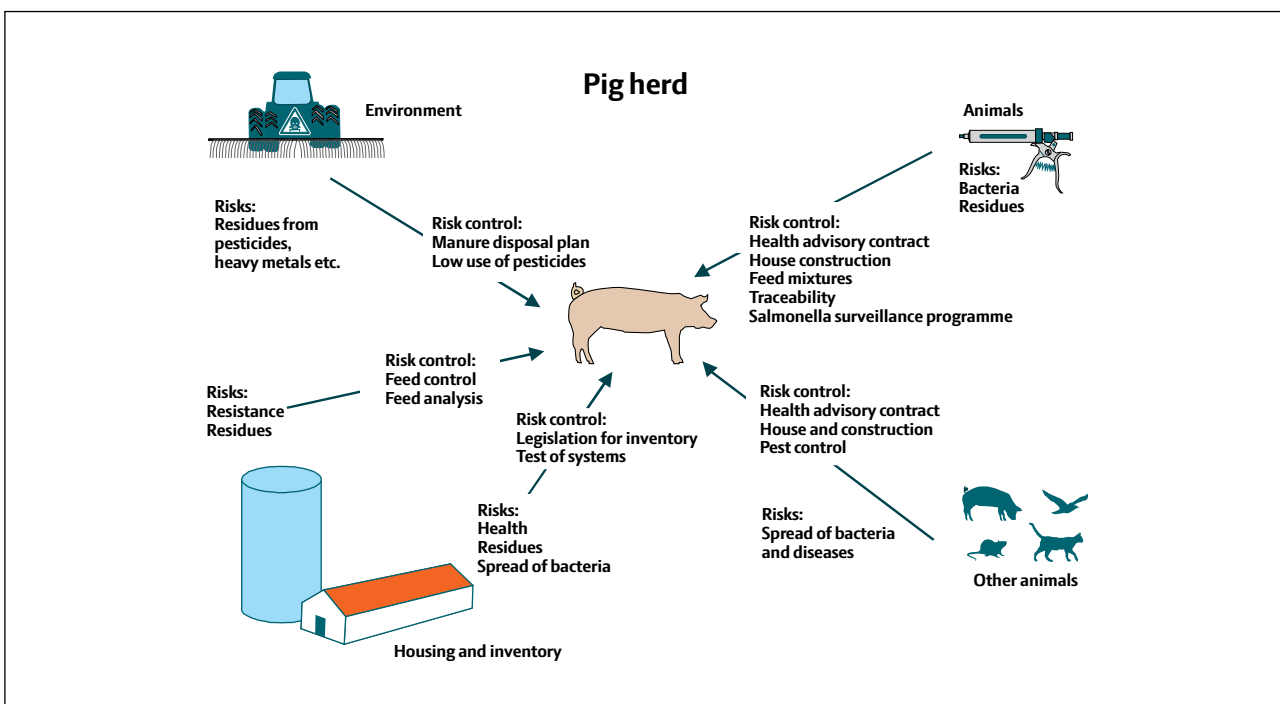


Figure 9: Risk management in Primary Production

In Denmark, the production of safe food is assured within a fully integrated system. Each stage of production, from breeding through to processing contributes to the delivery of safe meat and meat products.

Most food hazards occur as a result of faults in production, as a consequence of incorrect handling or processing, and can be divided into chemical, physical and biological risks.

5.1.1 Chemical risks: residues

Chemical risks may result from the presence of residues in meat. Residues may originate either from feed or medicine given to the

animals or in some cases from equipment and machinery or simply the production environment itself.

EU sets out legislation for the composition of feed. On the basis of current regulations, the Danish Plant Directorate audits all feed producers and the results are published on a regular basis. In addition, the preparation of industry guidelines, which utilise information from comparative trials, help ensure that pig producers use feed of the highest quality.

Sick animals may only receive medication from a veterinarian or the farmer, provided that the latter has a Health Advisory Agreement

with the veterinarian. Use of medication is only allowed following formal diagnosis by the veterinarian and any prophylactic treatment is forbidden in Denmark. By instructing the farmer in correct use of the medicine, the veterinarian ensures that the farmer is aware of the withdrawal period prior to delivery for slaughter. Use of hormones or other growth promoting substances is forbidden.

Danish legislation also requires that buildings and equipment must not be a source of substances harmful to pigs. Strict environmental laws also prevent the possibility of contamination by pesticides or heavy metals. The farmer must also obtain official approval for his slurry disposal plan.

5.1.2 Monitoring of residues

The Danish industry has built up a food surveillance system to detect the presence of residues in all foods including meat. The following categories of residues are included in the surveillance programme (See Appendix 8):

- Antibiotics and chemotherapeutics
- Hormones and growth promoting substances
- Pesticides
- Heavy metals.

The surveillance programme is planned by the Danish Veterinary and Food Administration and comprises statutory surveillance and a self-audit system. The level of sampling and detection limits for each residue is in compliance with EU legislation (96/23/EEC).

The statutory component of the surveillance programme is undertaken by The Danish Veterinary and Food Administration which carries out analysis and sampling. The self-audit component is performed by



As part of the companies' self-audit system, samples are analysed to detect presence of any unwanted residues in the meat. Between 18,000 and 20,000 samples of tissue from pigs' kidneys are tested every year. In the last ten years, the presence of antibiotic residues has been detected at levels between zero and 0.03% of the samples analysed. No presence of hormones has been identified and any presence of pesticides or heavy metal has always been below the permitted MRL's.

the slaughterhouses which are responsible for random sampling. The samples are analysed at the slaughterhouses by approved laboratories.

Antibiotics and chemotherapeutics

For the last 20 years, the Danish Veterinary and Food Administration has conducted random tests for residue concentrations of antibiotics and chemotherapeutics in meat in compliance with Danish legislation. The analyses are based on biological and chemical tests of kidney tissue in accordance with EU requirements.

In the last ten years, these analyses have detected minimal presence of residues of antibiotics and chemotherapeutics in the range of zero to 0.03% of the samples analysed. In recent years, between 18.000 and 20.000 samples per year have been analysed (See Appendix 8).

If the analyses carried out as part of the statutory surveillance reveal any presence of residues, the result is reported to the District Veterinary and Food Control Authorities, who then assess whether legislation has been transgressed, in which case the producer will receive a fine. A veterinarian visits the herd, usually in company with the local vet and a report on the use of antibiotics is then prepared. On the basis of this report, the District Veterinary and Food Control Authorities then decide whether the case should be submitted to the police for criminal investigation.

If the analysis from the self-audit system reveals presence of a residue **below** the permitted maximum level, the producer is informed and a report is produced as part of the self-audit documentation.

If presence is established **above** the permitted maximum level, the authorities are notified and a pig veterinarian will visit the herd to discuss improvements. A report is then sent to the producer and the slaughterhouse company, who then determine whether or not to add

the producer to a special list, which entails additional testing of future deliveries.

An example of the Danish approach is also provided by the action taken in respect of the antibiotic Sulphadimidine, whose usage for livestock is still permitted in some countries. A rise in the number of samples showing residues of Sulphadimidine in pigs began to appear in 1989 and 1990. Although the problem was primarily due to the substance remaining in the production environment rather than any malpractice by the farmer, it was decided to introduce a ban on its use in pig production in Denmark.

Hormones

There is a ban in the EU on usage of hormones for growth-promoting purposes. Since 1986, Danish meat has also been analysed on a random basis for presence of residues of hormones. The analyses for various hormones are conducted on samples of muscles, urine, blood and faeces. Residues of hormones have never been detected in Danish pork (See Appendix 8).

Pesticides and PCB

The use of chlorine-based pesticides and PCBs (Polychloride biphenyls) by farmers is not permitted, and nor must any such products be held in areas where food or feedstuffs are being produced. The use of DDT, Dieldrin and Lindane was banned in the early 1980s.

Since the 1980s, the Danish Veterinary and Food Administration has planned and conducted random tests for residue concentrations of pesticides and PCBs in food – both in animal and vegetable products (See Appendix 8). The random tests for pigs are performed on kidney fat and for a number of years only trace amounts of pesticides and PCBs have been detected. However, the maximum recommended limits have never been exceeded (See Appendix 8). Low levels of

residues of these substances are still occasionally detected because of their slow biodegradability.

Heavy metals

The random tests for residues of heavy metals in meat are undertaken by the Danish Veterinary and Food Administration (See Appendix 8). Samples of muscles, kidneys and liver are examined for residues of lead, cadmium and mercury and for trace elements of nickel, selenium and chromium.

For a number of years, only a single sample has revealed residues of heavy metals above the Maximum Recommended Level (MRL). The low levels of mercury and selenium have been unchanged in the last ten years, while that of cadmium, lead, nickel and chromium has been decreasing.

5.1.3 Physical risks

All extraneous matter such as bone fragments, cartilage, remnants of equipment and labels are regarded as foreign bodies.

Through strict enforcement of product specifications and comprehensive training of employees, the industry works to ensure that pig meat is free from bones, cartilage and other foreign bodies. In addition, all finished products are subject to detailed inspection. Where defects are found, these are rectified and the working processes are examined and steps taken to avoid any repeat occurrence.

5.1.4 Biological risks

Disease

Healthy livestock are crucial to production of safe food. Danish farmers seek to prevent transmission of diseases from the surrounding environment, through pest and insect control and by safeguarding the farm buildings against intrusion by predatory animals.

Good housing design and batch or multi-site production systems also help in ensuring high health levels.

Bacteria

The Danish industry implements rigorous controls to prevent the spread of pathogenic zoonotic bacteria. These are described in detail in Section 5.2.

Resistant bacteria

In Denmark, strategies have been implemented to prevent the development of resistant bacteria. This approach led to a ban on the use of the growth promoters avoparcin and virginiamycin and a voluntary ban on the use of all antibiotic growth promoters in Danish pig production from January 2000.

The Danish authorities monitor the development of resistant bacteria by regular analysis of random samples from animals, meat products and the human population (DANMAP).

Cleaning and personal hygiene

The Danish companies are responsible for the maintenance of hygiene standards during the production of meat and details must be made available to the Danish Veterinary Service.

The Danish Veterinary Service take samples from equipment to ensure that proper disinfection procedures are observed, as well as checking that specific hygienic requirements regarding clothing and personal hygiene are followed.

Comprehensive training programmes ensure that all slaughterhouse personnel learn the importance of personal hygiene as well as the need for prompt intervention if production faults occur.



The companies are responsible for control of hygiene and cleaning. Veterinary inspectors take samples from equipment and other inventory from the production lines.

Slaughter methods

In recent years, new slaughter techniques have been developed to improve hygienic quality and avoid cross-contamination.

Better hygiene is also achieved by more frequent use of automated procedures on the slaughterlines.

Also slaughterhouses have introduced a system using 'two knives', which are separately decontaminated in hot water (82 °C min.), thus preventing the spread of bacteria from carcass to carcass.

The rapid cooling of the carcass ensures a critical reduction in bacterial growth. According to the EU regulations laying down specific hygiene rules for food of animal origin (853/2004/EC), the inner temperature of a carcass must be reduced to maximum 7 °C immediately after slaughter, after which it may not exceed 7 °C. The temperature is maintained at this level by continuous surveillance and use of a buffer cooling room.

Buildings and equipment

Proper design and maintenance of the slaughterlines prevents the risk of introduction of bacteria and foreign bodies from buildings and equipment.

The Danish Veterinary Service check that the plant is properly maintained and ensures that there is constant production flow, which prevents cross-contamination between various products (e.g. raw materials and heat-treated products) and regular turnover of raw materials.

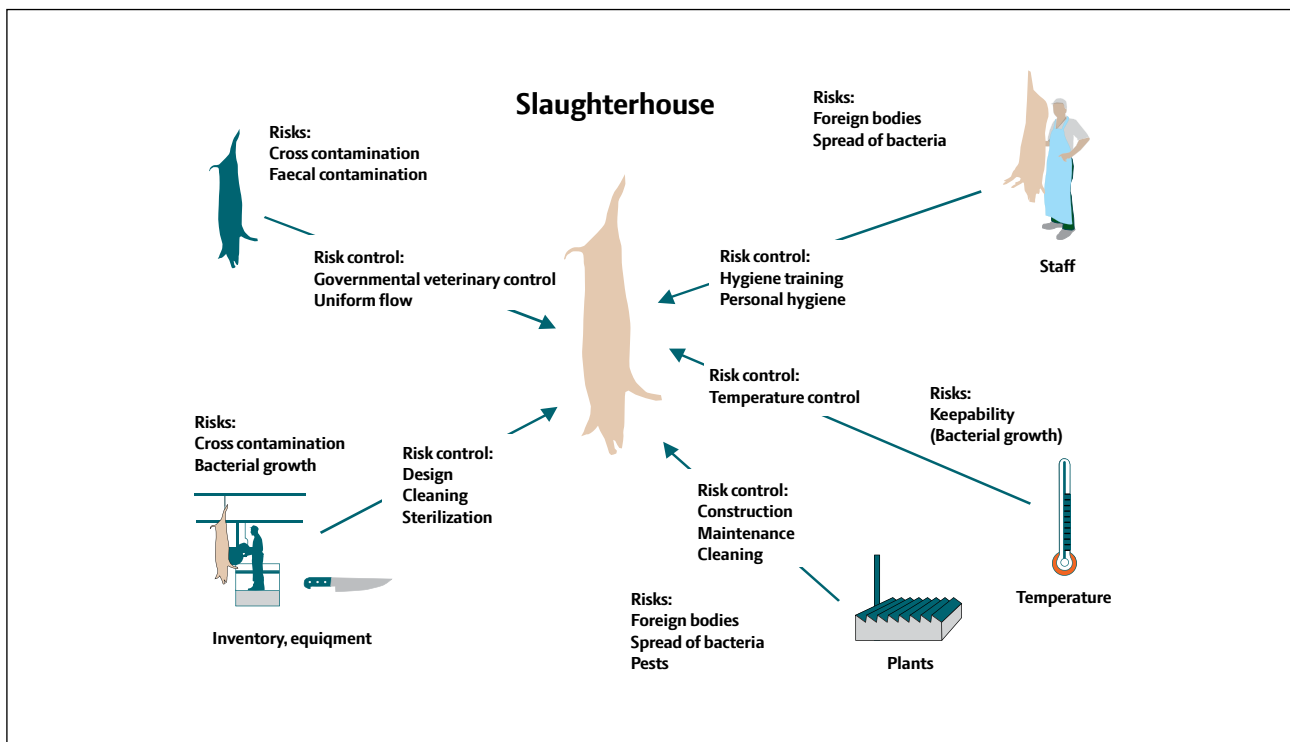


Figure 10: Risk management at the slaughterhouse

5.1.5 Risk management

Self-Audit Process

All Danish slaughterhouse companies have implemented a self-audit programme based on HACCP principles, which has been approved and is supervised by the Danish Veterinary and Food Administration.

Critical control points (CCPs) along the production chain are identified and described. Monitoring procedures are incorporated into the self-audit programme in order to control all food hazards (See Section 3.2.3).

Approval by the Danish Veterinary Service

Before the commencement of slaughtering, the company inspects the CO2 stunning facilities and slaughter lines to ensure all is in proper order. The inspection is part of the self-audit programme, which is supervised by the Danish Veterinary Service.

In order to ensure that only meat and offal from healthy animals is used, veterinary inspectors examine live pigs as well as the individual carcass and organs following slaughter.

When meat cuts are dispatched from the abattoir, the veterinary inspector also checks that the product specifications have been observed.

5.1.6 Summary

In addition to meeting all legal requirements, Danish companies take additional control measures to ensure the safety and durability of all meat products.

Since 1991, residues of antibiotics have been detected in less than 0.03% of samples analysed. Residues of hormones, pesticides and PCBs above the MRLs have never been detected. Only a single sample (in 1990) revealed an excess concentration of heavy metal above the permitted level.

5.2 Pathogenic bacteria and zoonoses

5.2.1 Legislation and industry agreements

In compliance with legislation affecting production of livestock and foods, the industry established a comprehensive Salmonella control programme, in collaboration with the Danish Veterinary and Food Administration. The programme comprises a number of voluntary control measures described below.

5.2.2 Zoonoses

Zoonoses are diseases, which can be transmitted from animals to humans. Food of animal origin is often the main source of contamination when humans are infected with zoonotic diseases. A number of bacteria can cause food borne diseases in humans, either as food poisoning or as food infection. Food poisoning is caused by pathogenic bacteria that produce a toxin in the food prior to its consumption. Food infections are characterised by a live bacterium, which itself induces disease.

A changing production environment, preservation methods and consumer behaviour all involve a risk of spreading of novel bacteria types. In addition, improved analysis techniques make it possible to detect new types of bacteria. The industry continuously assesses new bacteria types to evaluate their possible health risks. Major research is also focused on the development of quicker methods for detection of specific bacteria as well as mapping and controlling Salmonella.

Salmonella and yersinia bacteria originate from the same source (the digestive tract of the animal) and can be controlled in a similar manner.

5.2.3 The Salmonella surveillance programme

In co-operation with the Danish Veterinary and Food Administration, the Danish pig meat industry has launched a plan of action to reduce and control Salmonella in pigs.

The control programme for Salmonella comprises the surveillance of all Danish finishing herds delivering more than 200 slaughter pigs per year, special slaughter of pigs from Level 3 herds (see below) and monitoring of fresh pork at the slaughterhouse. In addition, all breeding and multiplier herds and sow herds selling weaners from Levels 2 and 3, are subject to controlled surveillance.

5.2.4 Salmonella on farm

In co-operation with government research establishments, the Danish pig meat industry has conducted extensive research into factors which are critical to the growth and spreading of Salmonella. The aim is to implement measures which prevent or reduce the occurrence of Salmonella.

Feed

All feedstuff companies must produce Salmonella-free feed. All ready-mixed feed from feeding mills must be heat-treated and the Danish Plant Directorate tests feed samples from all feeding mills.

Research has shown that home-mixed feed and fermented liquid feed generally offer better protection against Salmonella contamination due to the effect of the feed on gastro-intestinal health. The risk of Salmonella rises, therefore, when heat-treated feed is used in Salmonella infected herds rather than feed mixed by the producer himself.

The addition of very small amounts of organic acids in feed and drinking water has also been found to reduce the occurrence of Salmonella in pigs, probably because of the effect on microbial conditions of the intestinal tract of the pig.

Transmission between animals

“All in - all out” management or ‘batch production’, with disinfection between each batch of pigs, minimises the risk of Salmonella transmission between groups of animals and is very effective in combination with other Salmonella reduction programmes.

Declaration of Salmonella status

All producers are obliged to provide information on the Salmonella status of their herd. When selling live animals, the following information must be provided:

- Salmonella level of finisher herds
- Salmonella Index of breeding and multiplying herds
- Salmonella detected in faecal samples (any herds).

5.2.5 Salmonella at the abattoir

Salmonella exists in the digestive tract of the pig (the mouth, throat, stomach and intestines).

The greatest risk of bacteria spread at the slaughterhouse is at the stage when the stomach and intestines are removed from the carcass. To counter this, a series of preventative measures have been taken at Danish slaughterhouses.

Pigs may not be fed any later than 12 hours before slaughter and they must have access to water ad libitum, because removal of a full stomach increases the risk of perforation with ensuing contamination. Other measures involve use of a ‘fat end’ bag and decontamination of all equipment in hot water (82 °C) - See Section 3.

Slaughter of pigs from Salmonella infected herds

Pigs from Salmonella infected herds (Level 3, see below) are transported separately to the slaughterhouse and slaughtered under increased hygienic conditions.

During the slaughter process itself, preventative measures are also taken, e.g. additional personnel are available on the slaughter line or carcasses are sprayed with hot water (82 °C). The use of hot water is very effective in reducing any occurrence of Salmonella. In addition, the slaughterhouse may use a hand-held steam suction device as steam can reduce any carcass contamination. The latter method is not reserved for Level 3 pigs.

To avoid contact with a contaminated oral cavity and throat, splitting of the head of the carcass is not performed. Plucks from Level 3 pigs are condemned or heat-treated since they may not be used for ordinary consumption.

Intensified Salmonella surveillance

In addition to monitoring finisher herds (cf. section 5.2.7) the slaughterhouse also conducts a Salmonella surveillance programme. If the occurrence of Salmonella exceeds a set limit, the slaughterhouse must draw up a plan of action and corrective actions must be taken. Together with the other measures taken, intensified surveillance at slaughterhouses ensures constant focus on minimising the presence of Salmonella.

5.2.6 Monitoring of breeding and multiplying herds

Salmonella monitoring in breeding and multiplying herds has been compulsory since 1998. Ten blood samples are collected from all breeding and multiplying herds every month. The samples are submitted for analysis for presence of Salmonella antibodies. If the samples

show signs of Salmonella infection, pen samples are obtained to determine the type of Salmonella and identify the areas where the Salmonella infection has occurred. At the same time, the producer is recommended to draw up a plan for the reduction of the occurrence of Salmonella.

Herds with an increased level of occurrence are subject to a fine per breeding animal sold.

5.2.7 Monitoring of production herds

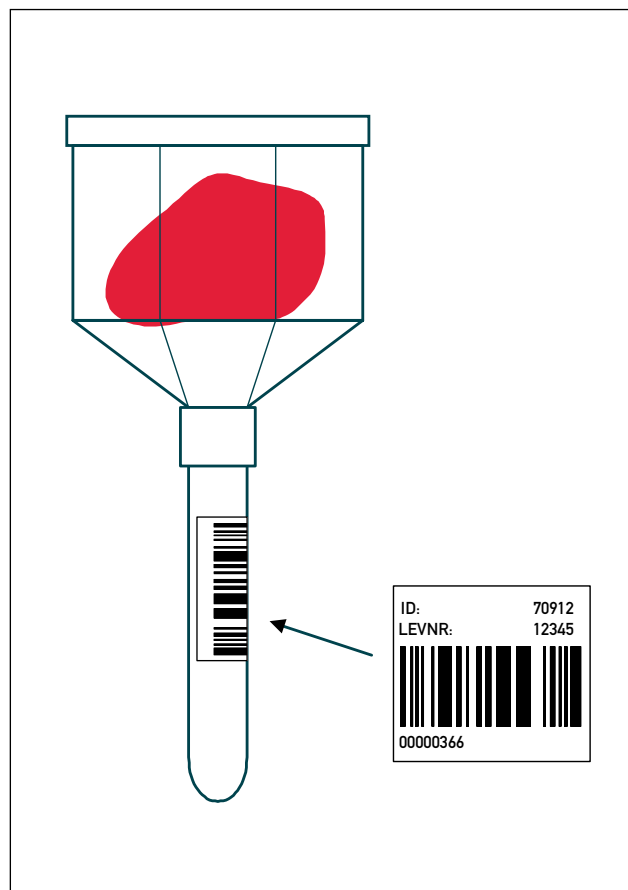
Sow herds

Sow herds delivering piglets to finishing herds, where Salmonella problems have been identified (Levels 2 or 3, see 5.2.8) must be notified to the Veterinary Department of the Danish Agriculture & Food Council (Landbrug & Fødevarer). The producer must submit faecal samples to determine whether the source of the infection in the finishing herds is related to the sow herd in question.

Finishing pigs

If a pig becomes infected with Salmonella, its immune system starts to produce antibodies between two and four weeks. During the period of infection, the number of antibodies remains high and begins to decline when the infection subsides. The presence of Salmonella antibodies therefore indicates that the pig has been infected. The level of antibodies is therefore used as an indication of the level of Salmonella in the herds.

The level of Salmonella antibodies – the Salmonella value – is determined by an ELISA test. The samples are categorised as positive or negative samples. If the level of positive samples in a herd begins to increase, it may be an early warning that action has to be taken.



Salmonella surveillance of pig production herds is based on meat samples taken at the slaughterhouses. The samples are analysed for presence of salmonella antibodies and each herd has its salmonella level registered.

For herds that produce more than 200 finishing pigs a year, a number of samples for these tests are collected randomly according to the number of pigs produced. Carcasses that are to be tested are automatically selected after weighing at the abattoir. A meat sample of about 10g is removed and placed in a container and labelled so that pig and herd can be identified.

The sample is frozen and submitted for analysis. The results are collected in a Zoonosis Register managed by the Danish Ministry of Food, Agriculture and Fisheries.

The results of Salmonella surveillance are assessed monthly and this information is communicated to the pig producer, together with payment details from the slaughterhouse. The monthly record includes the producer number, date of sampling, number of samples collected and the proportion of positive and negative samples. The result of the last six months surveillance of the herd also appears on the record. Part results for each supplier number are also submitted each time payment is made to the producer. Thus, the producer and his advisers can carefully monitor the Salmonella status of the herd.

5.2.8 Determination of Salmonella level

Based on the samples collected in the previous three months, a monthly index is calculated for the herd and the level is determined as follows:

- Level 1: None or few positive samples. Action is not required
- Level 2: A larger number of positive samples. The herd owner must contact a production adviser to draw up a plan for the reduction of Salmonella
- Level 3: The number of positive samples is too high. The herd owner must contact a production advisor. In addition, all pigs from the herd must be slaughtered under increased hygienic conditions

Herds classified as Level 2 or 3 have to submit faecal samples for analysis to determine the extent of the infection and the type of Salmonella.

Salmonella slaughter deduction

If a herd has been classified as Level 2 or 3, a deduction will be made from the payment to the pig producer as shown below:

Salmonella level	% deduction in carcase value
Level 2	2%
Level 3 (first 6 months)	4%
Level 3 (over 6 months) ¹⁾	6%
Niveau 3 (over 12 months) ²⁾	8%

1) The first time a herd is rated Level 3, 4% of the carcase value will be deducted. If the herd returns to Level 3 during the subsequent five months, the 4% deduction remains in force. After that, it increases to 6%. If the herd reverts to Level 3 again over the subsequent 5 months, the deduction remains at 6%.

2) If the herd remains at Level 3 – and has been subject to a deduction of 6% at any given time during the previous 12 months – the deduction increases to 8%. Once the herd has been out of Level 3 for 12 successive months, the deduction will fall to 4% the next time the herd is classified at Level 3.

5.2.9 Control

All feedstuff companies are inspected every quarter, either by the Danish Plant Directorate or by means of an approved Code of Practice, which is implemented by the industry. In addition, the Plant Directorate takes feed samples for Salmonella testing.

The breeding and multiplying herds are also tested for Salmonella infection by means of blood samples collected by the herd veterinarian. The samples are analysed in an approved laboratory. If the analysis reveals too high a level of positive samples, then further faecal samples are taken from the herd.

In production herds that deliver more than 200 finishing pigs per year, serological tests are taken in proportion to the number of animals delivered. Based on these samples, the Danish Veterinary and Food Administration allocate a Salmonella level to all finishing herds.

Pigs from Level 3 herds are slaughtered under increased hygienic conditions. They are also checked for contamination with Salmonella bacteria. If Salmonella is detected over a set limit, the carcasses are heat-treated to destroy the bacteria.

Every month, samples from fresh, chilled carcasses are collected for Salmonella analysis. In 2009, this monitoring programme showed Salmonella presence in around 1.2% of the samples analysed.

5.2.10 Summary

The Salmonella Surveillance Programme in Denmark makes it possible to monitor the occurrence of Salmonella throughout the production chain. The programme has been successful in limiting the spread of Salmonella in Danish pigs and kept the level to a minimum in finished products.

The Danish Zoonosis Centre estimated that in 2009, 162 persons were infected with Salmonella from Danish pig meat compared to around 1,100 in 1993.



Fresh meat is also tested for presence of Salmonella, with samples taken from carcasses at the chilling stage. In the year 2009, only 1.2% of these samples taken tested positive for Salmonella.

5.3 Influence on meat quality

Parameter	Section	Quality traits							
		Uniform size	Lean meat percentage	IMF	Colour, appearance	Drip loss PSE/DFD	Taste and smell	Tenderness	Durability
Breeding	(1.1-1.2)								
Cross-breeding	(1.2)								
Feed	(1.6)								
Housing conditions	(1.3-1.5)								
Transport/lairage/stunning (animal welfare)	(2.1-2.4)								
Slaughter	(3.4-3.9)								
Cooling, cooling chains, down-freezing	(3.11, 4.2, 4.5)								
Grading	(3.10-4.2)								
Cutting	(4.2-4.3)								
Packing	(4.4)								

Meat quality is assessed against a number of parameters. As has been described in earlier Sections, their significance varies from product to product.

The table above shows how individual quality parameters influence various quality traits throughout the production chain. By integrating the effects of the individual parameters, overall quality levels can be maintained.



Danish pigs are very uniform in size. Using data from grading and weighing the carcasses can be carefully selected to ensure product consistency.

5.3.1 Meat quality traits

DFD: DFD means Dark, Firm and Dry. DFD meat occurs when pigs are stressed at the time of slaughter, which causes their glycogen deposit to be used up. The result is a high pH level in the meat, as formation of lactic acid is prevented. This ensures good water holding capacity but can reduce product durability. DFD does not normally occur in Danish pork.

PSE: PSE means Pale Soft Exudating. A combination of genetics and environment results in PSE. PSE meat often arises from pigs carrying the Halothane gene, which is affecting the cell membrane and the water binding ability. Pigs bearing this gene are more easily stressed. The Halothane gene is no longer found in Danish pigs.

Uniform size

In Denmark, the average slaughter weight is between 81 and 82 kilos (equating to a live weight of 110 kg). As a result of the integrated production system, the size of Danish pigs is very uniform. Moreover, based on data from grading and weighing, the slaughterhouses can carefully select carcasses and chose cuts of a consistent size.

Lean meat percentage

The payment to the pig producer depends on slaughter weight and lean meat percentage. The grading system ensures that the abattoir knows exactly the lean meat percentage of the key areas of the carcass. This allows the slaughterhouse to select cuts of similar lean meat percentage.

Danish pigs have an average lean meat percentage of around 60%, which makes it well suited for further processing and providing a lean product.

Intramuscular fat (IMF)

The meat's intramuscular fat content affects the taste, tenderness and juiciness of the fresh meat. A high IMF content means that the meat can accommodate variations in maturing and processing methods more easily, thus maintaining the eating quality, which is important for retail cuts. When the meat is used for further processing, a low IMF content is required because the leaner the meat, the greater the capacity for proteins to absorb brine and other ingredients used for further processing.

Trials have shown that an IMF content of around 2% is optimal for both retail cuts and processing. At an IMF content of 2%, the meat is sufficiently robust, has a good eating quality and is suitably lean for processing. At an IMF of 2%, the fat content is just visible.

In general, Danish pig meat is lean. For loin and similar cuts, the IMF content averages around 1.5% making it ideal for further processing as well as retail cuts.

Colour, appearance

The pigment content especially affects the colour of the meat and this increase with the age of the pig. As a result of the younger age of the pig when slaughtered, the colour of Danish pork tends to be light, but this may also be affected by the feeding method or breed, or indeed a combination of all three factors.

The appearance of meat may be impaired if the pigs are stressed during transport, lairage and stunning. Stress can cause PSE or DFD meat as described below.

Some stunning methods can cause blood splashing which affects the appearance and the durability of the product. CO₂ stunning, as used in all Danish slaughterhouses, has reduced the extent of blood splashing to a minimum.

Drip loss / PSE / DFD

The pH level and a number of other factors affect the drip loss in fresh and frozen pork.

Immediately after slaughter, the pH level in meat falls as a result of the production of lactic acid in the muscle fibres. The pH reduction is stopped by cooling the meat as rapidly as possible after slaughter. At the same time, the chilling process has been optimised to minimise drip loss. This is achieved by reducing the average temperature of the meat to less than 7 °C without formation of ice crystals within the muscles of the meat resulting in a carcass temperature of 7 °C after 24 hours.

If the pigs are exposed to stress during transport to the abattoir, lairage and stunning, there is a risk of PSE meat (acute stress) or DFD meat (if the animals are exhausted). These factors render the meat unsuitable for processing.

Genetic traits also have an influence on PSE levels. After the removal of the Halothane gene from the Danish breeding system, the pigs have become less sensitive to stress and thus less inclined to develop PSE characteristics. This has resulted in low PSE prevalence (less than 2% in loin) and the absence of DFD characteristics.

Taste and smell

Fresh pork has a relatively mild taste and smell. The eating quality of pork is strongly influenced by the production method but the IMF content (see above) and the composition of fatty acids also plays

a role. The composition of fatty acids can be controlled through feedstuffs. Therefore, the industry has developed guidelines for the composition of pig feed. In particular, there are fixed limits for the maximum content of strong tasting ingredients such as fishmeal.

Tenderness

The tenderness of the meat depends on the IMF content, the age of the animal, cooling of the carcass, the process of maturation and further processing. In addition, it also depends on the amount of connective tissue in the individual cut. Cuts from the belly, hock and fore-end contain most connective tissue and therefore seem to be tougher than the muscles of the back. The linkages of connective tissue have a particular effect on toughness. Meat from young animals is more tender than meat from older animals since the number of cross-links increase with age. Danish pigs are around six months of age at slaughter.

Chilling of the warm carcass also influences the tenderness of the meat. If chilling is carried out too quickly, cold shortening occurs which causes the meat to be tough.

Maturation of the meat within 3 days or so, at a maximum temperature of 5 °C, ensures tender meat, as a result of the enzymatic degradation of some of the proteins that bind the meat.

Durability

The durability of meat depends on a number of factors such as feed, storage temperature, and hygiene during slaughter and cutting, as well as the packaging method used.

Because of the high hygiene levels in Danish abattoirs, the most significant factor for the durability of Danish pork is normally fat rancidity.

Thus, cuts with high fat content tend to have lower keepability than leaner cuts.

The composition and quality of pig feed also affects keepability of meat, as the fatty substances in pig feed do not have the same durability. In Danish pork, the composition of fatty acids is usually around 45% monounsaturated, 15% polyunsaturated and around 40% saturated.

Animal welfare

All aspects of housing and pig handling are governed by EU regulation. Danish legislation and industry rules also apply and these ensure high animal welfare levels at all stages of production, during transport and during the pre-slaughter stage at the abattoir.

5.3.2 Summary

The results of the action at all stages of the production chain ensure the following characteristics:

- Lean meat
- Uniform size of cuts
- Tender and tasty meat
- Good animal welfare
- Low prevalence of unfavourable quality traits (blood splashing, PSE and DFD)
- Good durability.

All these factors contribute to a product of high quality.

5.4 Quality management and control of the slaughter processes

This section describes the common features of the quality control systems applied at the co-operative slaughterhouses within the Danish pig meat industry.

5.4.1 Legislation and industry agreements

All companies have implemented various types of quality control programmes based on prevention rather than control and linked to HACCP principles. Quality control targets relate to a number of key parameters such as taste, appearance and other attributes.

Some of the companies' quality control systems are identical. In relation to quality control, the companies have implemented the Global Red Meat Standard (GRMS) which, in addition to HACCP requirements and quality control systems, also ensure product consistency (see www.grms.org).

Production systems must ensure optimum quality. New equipment must be designed to ease the working process but also minimise the risk of production faults.

Detailed working procedures have been developed for each stage of the process. These procedures are part of the basic job description for individual operators and are carefully followed. Each operator does not perform any re-inspection of the proceeding parts of the process. Only cuts with readily identifiable defects are rejected.

5.4.2 Process control

On the slaughter line, the control of quality and food safety is almost one and the same. Therefore, many aspects of quality control are covered by the company's approved self-audit system.

In addition, the Danish Pig Classification Authority (under the control of the Danish Ministry of Food, Agriculture and Fisheries) tests the



On the slaughter lines, control of quality and food safety are almost one and the same. Therefore, many aspects of quality control are covered by the companies' approved self-audit system.

processes relating to grading and payment (e.g. treatment of rind and removal of tonsils).

All cuts are produced to meet detailed specifications. If non-compliances occur, the process is immediately corrected. Re-inspection of any rejected cuts is carried out according to specific rules.

Yield control is based on weight checks carried out at various stages of production. The carcass weight allows the company to predict the weight of individual cuts. If there is a difference between actual and expected weight, this may be due to incorrect cutting which is then investigated and rectified.

5.4.3 Verification

The effectiveness of the quality control system is tested by spot checks at specific stages of the production process and random samples of the finished product. Critical control points have been identified along the production chain. Specific limit values and numbers of permitted

deviations have been established before corrective actions are taken. Certain deviations are not permitted, but the majority is weighted according to a scoring system. Limit values for the sum of deviations are then calculated rather than simply assessing the value of each particular deviation.

The results are collected daily and communicated to relevant management, so corrective action may be taken immediately. The results of the spot checks are used to indicate longer-term trends so emerging problems can be identified and resolved at an early stage.

The increase in automation of slaughterline equipment has led to increased demands on process control, as the quality of each process is more dependent on the quality of previous processes.

5.4.4 Summary

All co-operative slaughterhouses in the Danish pig meat industry have developed comprehensive quality control systems. Systematic re-inspection verifies uniform high quality of the finished products. For the purpose of additional quality assurance and documentation, the slaughterhouses have implemented the Global Red Meat Standard (GRMS).

5.5 Traceability

Marking, registration and documentation is undertaken at all stages of pork production. The purpose is to maintain the overall safety of Danish pork and, more specifically, ensure that:

- The meat is of Danish origin and comes from healthy animals
- The meat is free from food hazards.

The Danish system allows pork to be traced back to the place of slaughter and then back to a small group of farms, who delivered pigs on a particular day.

5.5.1 CHR Identification

In Denmark, all cattle and pig farms are registered with a herd number, the CHR number, in the Danish Ministry of Food, Agriculture and Fisheries' Central Husbandry Register (CHR). The register contains up-to-date information on:

- Herd number (CHR number)
- Name and contact information of the owner, manager or tenant
- Name and contact information of the owner
- Address of the farm where the herd is kept
- Species of animal and production type (e.g. finisher pigs)
- Average number of animals
- Name and contact information of the local veterinarian attending the herd
- Supplier number applied to pigs before delivery for slaughter.

The CHR number is used in all contact with the authorities, including the ongoing Salmonella control system.

The CHR system provides an overview of all herds in Denmark. A herd can be quickly identified together with information relating to all other herds in the same area. By means of the CHR numbering

system, it is easy to combine a large amount of data on the herds. This can be utilised for research purposes when well-defined sampling is needed or to investigate factors contributing to the spread of disease.

In case of more serious disease outbreaks, the CHR register makes it possible to stop the movement of pigs in a defined area immediately, thus avoiding disease spread.

5.5.2 Marking, registration and documentation

The key elements of the marking, registration and documentation of pigs and pig meat are shown in the following two charts. The first (Figure 11), covers Marking, with the letter 'M' representing each key stage. The second (Figure 12) covers Registration and Documentation, with the letter 'D' representing each key stage.

Earmarking of pigs

In Denmark, all pigs must be marked with an approved ear tag before the animals leave the herd of origin, i.e. the herd of birth (M1). The following exceptions are allowed:

- Pigs, which are tattooed on the gammon and transported directly to a Danish slaughterhouse (M3)
- Casualty pigs going for rendering
- Batches of pigs, which are moved without being traded (e.g. within multi-site systems)
- Batches of pigs, which are transported under a fixed agreement between seller and purchaser (M2).

The ear tag must be approved by the Danish Veterinary and Food Administration and bear the CHR number of the herd in which the earmarking was carried out.

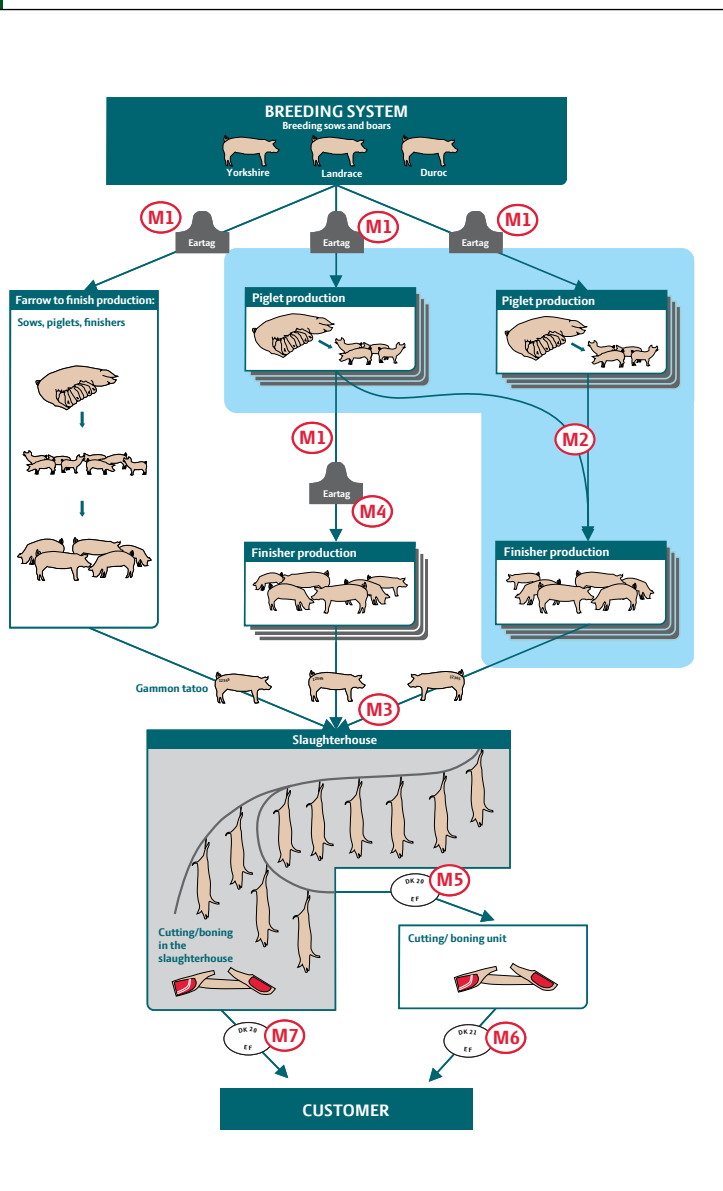


Figure 11: Marking of pigs and pork

Breeding traits

The Danish pig breeding programme, DanBred, seeks to improve the selected breeds. The results of the genetic work are passed on to commercial production through sales of breeding animals and semen. Documentation accompanies each breeding animal providing breeding traits, breed combinations, health status, etc. (D1). This information is also collated in the records of the breeding herd itself.

Registrations by the farmer

The farmer must record all pigs entering and leaving the herd as well as the CHR number of both the supplier and recipient of pigs (D2). The majority of Danish pigs remain on the farm of birth. A number of piglets are sold after weaning. Approximately 80 per cent of the domestic trade in piglets is based on fixed agreements between a finishing herd and one or several producers of piglets in so-called 'pig rings'. In addition to price and information relating to the health status of the herd of origin, the delivery agreement usually includes a complete health certificate (D3).

As part of this agreement, a transport document (D4) must accompany each batch of pigs providing information about the following factors:

- CHR number, name and address of supplier and purchaser
- Name and address of haulier
- Number of animals
- Date of transfer.

By only receiving piglets from one or a few known herds (no more than five) a producer may effectively safeguard his herd against introduction of disease in the best possible way. At the same time, the origin of the pigs delivered can easily be documented.

The remaining 20 per cent of the domestic trade in piglets takes place via a pool arrangement (M4), in which a purchaser receives piglets from different pig producers (whose herds may also be identified by means of ear tags). The piglets are sold before they leave the herd, ensuring that the purchaser is always known. The purchaser will also know the health status of the piglets.

In addition to the registration made by the farmer, the haulier must record the date of transport, number of animals, the supplier and purchaser for all pigs, which are not sent directly to a Danish slaughterhouse (D5).

Both types of delivery agreements must be accompanied by transport documents ensuring that the purchaser always knows the supplier of piglets. Thus, it is not possible to receive pigs of unknown origin in Denmark.

Veterinary Medicine

Danish pork must be free from veterinary residues and stringent rules govern the use of antibiotics for pigs. The veterinarian may only prescribe antibiotics after a specific diagnosis. The veterinarian then issues a prescription for the medicine with a written instruction on its proper use stating the withdrawal period (D6). The veterinarian keeps a journal of all the herd visits in which medicine was prescribed. At the same time the farmer must record the use of medicines and the animals treated (D2).

Marking of pigs sent for slaughter

The slaughterhouses only receive pigs directly from producers. The transport of pigs for slaughter is co-ordinated by the slaughterhouse, which has a contract with each haulier. The haulier has to retain information relating to place of dispatch and destination and the owner of the animals.

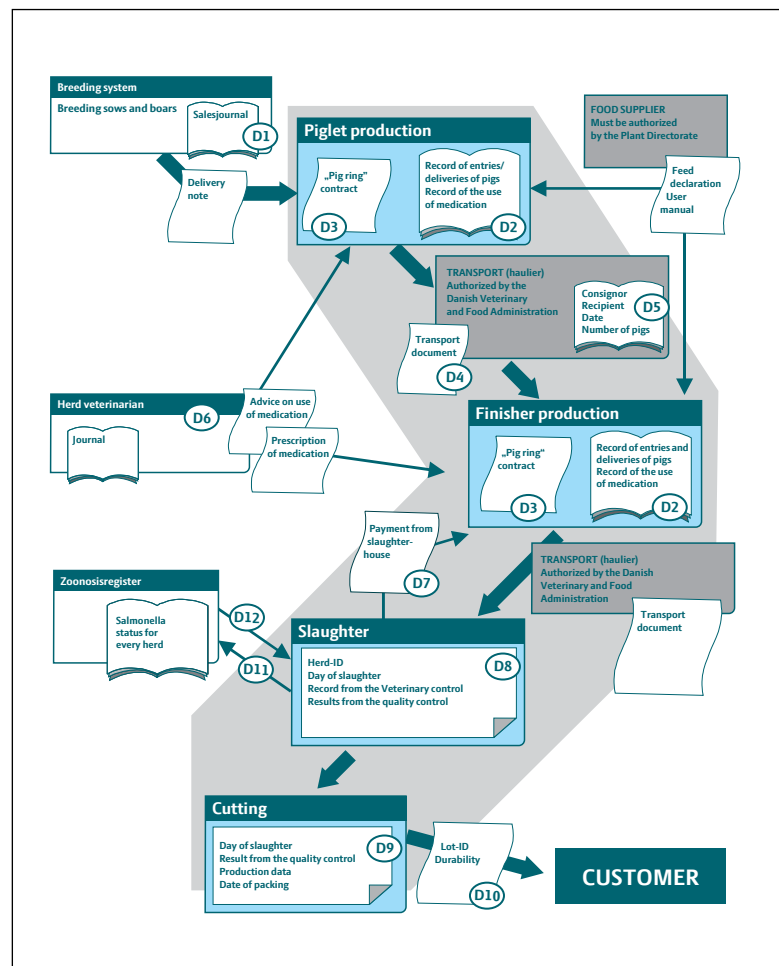


Figure 12: Registration and documentation

Before the pigs are loaded, the pig producer must mark all his pigs with a five-digit number (M3) on each gammon as laid down by EU regulations (92/102/EEC), in order that the abattoir can identify the supplier.

Registration at the slaughterhouse

During the slaughter process and no later than the weighing of the carcass, the ID number of the gambrel is automatically read and manually linked to the supplier number. Both numbers are stored as one in a computerised system (D8).

All data generated on the slaughter line (weight, lean meat percentage, presence of coloured hair follicles, veterinary observations), are linked to this number in the computer via automatic readings of the ID number of the gambrel.

Control, collection and publication of the results from Salmonella surveillance and other specific bacteriological examinations are also handled via the supplier number and the ID number of the gambrel.

The data accessed from the computer is used to calculate payment to the pig producer (D7). In addition to the data directly related to payment (weight and lean meat percentage), the producer receives other information which is relevant to his production, including any formal observations or remarks by the veterinary inspector.

Only carcasses approved by the veterinary inspector can be sent on for chilling and cutting. Data from the weighing and grading procedures are used for grading carcasses (D9). Carcasses with similar characteristics are collected and used selectively to ensure the best possible uniformity in finished products.

Identification after the veterinary inspection

After the pigs have been slaughtered and declared fit for human consumption by the veterinary inspector, the carcasses are stamped in accordance with the EU regulations (854/2004/EC) with an EU-approved authorisation number, which is allocated to the company by the Danish Veterinary and Food Administration (M5).

If carcasses are cut in a separate plant, the meat must be marked with the authorisation number of the cutting plant as laid down in the EU regulations (853/2004/EC). If cuts are delivered to produce meat products at a separate plant, they must be marked with the authorisation number of the plant (M6). If slaughter, cutting and production are performed at the same plant, only one registration number needs to be applied (M7).

In compliance with the EU's food products regulation (178/2002/EU) and the hygiene regulations for food of animal origin (853/2004/EU), meat cuts and meat products must be accompanied by information identifying the specific lot number (D10). If a date of minimum durability or the 'use by' date is labelled on a product, this information may be used as lot-ID provided that the date consists of at least the day and month. For non-pre-packed products, the information related to the lot may be contained in accompanying commercial documents.

Retail packed meat must be labelled with the name of the distributor, or the company packing the product, or the manufacturer of the product in conformity with the EU Council directive (2000/13/EEC)

Identification of pigs and pig meat

	Identification	EU legislation	Danish legislation
Producer (sales of piglets)	Ear tag (M1)	92/102/EEC	Regulation No. 1066/2005
Producer (to slaughterhouse)	Producer No. (M3)	92/102/EEC	Regulation No. 1066/2005
Slaughterhouse	Authorisation No. (M5)	853/2004/EC	853/2004/EC
		854/2004/EC	854/2004/EC
Cutting plant	Authorisation No. (M6)	853/2004/EC	853/2004/EC
		854/2004/EC	854/2004/EC
Production plant	Authorisation No. (M6/M7)	853/2004/EC	853/2004/EC
Meat cutting	Authorisation No. + lot-id	853/2004/EC	853/2004/EC
Meat product	Authorisation No. + lot-id + declaration	853/2004/EC	853/2004/EC
		2000/13/EC	Regulation No. 1308/2005

5.5.3 Traceability

Meat at retail level can be traced back to the cutting plant by means of the authorisation number of the plant (M6/M7).

In accordance with EU regulations (2000/13/EEC), the name of the manufacturer or distributor must appear on the packaging. The company is then able to trace back the product on the basis of information on the product type.

On retail packaging, the meat must be labelled with the manufacturer or packer's EU-approved authorisation number in addition to the lot identification. By means of the authorisation number, all fresh meat and meat products can be traced back to the plant where the meat was last processed (M6/M7).

If the meat has been cut or processed at a separate plant, the product can be traced to the slaughterhouse by means of documents accompanying the meat. Based on the lot identification documents, the slaughterhouse can trace back the product to the date and time of production (D10) and, thus, find additional specifications of the meat (e.g. weight, lean meat percentage). On the basis of the product specifications, the slaughterhouse is usually able to trace the meat back to a group of carcasses, since the carcasses were identified in accordance with these specifications (D9, D8). The serial number of the carcasses is attached to the supplier number on the basis of which the meat can be traced back to a group of pig producers (D8).

5.5.4 Application of the system in practice

Pigs from herds delivering more than 200 slaughter pigs annually are tested for Salmonella antibodies by a programme of random sampling at the slaughterhouses. The number of samples is determined by

the number of slaughter pigs delivered to the abattoir and the specific herd's current Salmonella status. The carcasses to be tested are selected after weighing at arrival to the slaughterhouse. When a carcass has been selected for examination, the Danish Zoonosis Register is informed of the supplier number of the herd (D11). After classification and marking, a meat sample of 10g is collected. The sample is stored in a special container labelled with a bar code containing the supplier number, the ID number of the gambrel, slaughterhouse and so on, to ensure unambiguous identification of the supplier of the carcass. The sample is frozen and submitted to an approved laboratory, which conducts the analysis for presence of Salmonella antibodies.

In the Zoonosis Register, the supplier number is linked to the CHR number. When the result of the sample analysis is known, it is linked to previously held registrations to obtain the Salmonella status of the herd. The result is sent to the slaughterhouse (D12). Every month, in conjunction with his payment from the slaughterhouse, the pig producer receives information about the result of each meat sample (D7) as well as a complete statement of the Salmonella level of his herd.

This detailed and rapid response from the Salmonella screening programme enables each pig producer to be kept informed of any changes in his herd's Salmonella status at an early stage. In this way, the pig producer and his advisors are able to monitor the Salmonella status of the herd very closely.

5.5.5 Tracing to the herd of origin

The origin of every pig moved is known throughout the production chain. If a recipient identifies any errors these can be immediately corrected. When a pig is moved, both the supplier and the purchaser record its origin and destination. This double set of records ensures that all pigs in Denmark can be traced, allowing quick intervention in case of disease outbreak.

Traceability information at the slaughterhouse is used practically in the management of the Salmonella Surveillance Programme. Records are also utilised at the slaughterhouse in other areas, such as residue surveillance.

The common rules adopted by Danish pig producers and the full traceability of all Danish pigs assure the production of safe and high quality pig meat.

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Appendix 1 Use of veterinary medicines

Extracts from regulation regarding veterinarians' use, supply and prescription of medicines for animals (Reg. No. 482/2007)

Section 3:

"Prohibition of and restriction in use of specific hormones etc."

§ 9

The use of veterinary medicines or substances mentioned in Appendix 3 is banned (Appendix 3: Thyrostatics, stilbenes and stilbene combinations).

2) Veterinary medicines with thyrostatic effect may be used for the treatment of dogs and cats with hyperthyroidism providing the veterinarian records such usage in accordance with § 34 section 1, nos. 1&2 and nos. 4-8.

§ 10

Use of veterinary medicine or substances with androgen, gestagen or oestrogen effect and of beta-agonists for livestock or fur animals is prohibited, c.f., however, §§ 13-16.

§ 11

Use of veterinary medicine or substances with hormonal or hormone-like effect for livestock and fur animals for growth or performance-enhancing purposes is prohibited.

Section 4:

"Veterinary medicines restricted to veterinarian use"

§ 17

The treatment of animals with prescription medicines consisting of the following may only be performed by the veterinarian personally

and the veterinarian may not supply or prescribe the medicines:

1. Analgesics for injection, excluding non-steroid anti-inflammatory medicines,
2. Anaesthetics for inhalation or injection
3. Opioides, opiates, barbiturates, benzodiazepines and psychosedatives
4. Seleniferous substances for injection
5. Parasympatomimetics for injection and parasympatolytics for injection
6. Sympathomimetics for injection and sympatholytics for injection
7. The following hormones and other compounds with hormone-like effect for injection:
 - a) adrenocorticotrope hormones
 - b) natural and synthetically produced adrenal steroids
 - c) oxytocin and oxytocin analogues
 - d) prostaglandines and prostaglandine analogues
8. Fluoroquinolones for injection, and
9. Medicines exclusively approved for intravenous administration

2) Notwithstanding sub-section 1), no. 3, a veterinarian may supply or prescribe opioides, opiates, barbiturates, benzodiazepines and psychosedatives for oral administration to other animals than livestock.

3) Notwithstanding sub-section 1), no. 7, letter C, a veterinarian may supply or prescribe oxytocin or oxytocin analogues for treatment of other diseases than labour pain stimulation for use in

- a) pig herds without Health Advisory Agreements for posttreatment of up to 5 days, provided the vet has initiated treatment of each individual animal,
- b) pig herds with Health Advisory Agreements for up to 35 days.

Appendix 2 List of prohibited materials in feed

The Danish Plant Directorate's Regulation No.1177/2007

The following raw materials may **not** be used in feed mixes:

- a) Manure, urine including intestinal contents and waste
- b) Leather and cuttings
- c) Seeds, grains and plants treated with fungicides
- d) Wood, sawdust etc. from any trees treated with wood preservative
- e) Sewage sludge
- f) Solid urban waste, for example, household rubbish
- g) Catering and similar wastes excluding discarded food products of vegetable origin
- h) Food packaging and other remnants
- i) Animal protein

Appendix 3 Tolerances for feed mixes for pigs

General nutrients – minimum levels

Raw protein*:

2.0 units in the case of a declared content of a minimum of 20%
10% of the declared content in a case of more than 10% (up to 20%)
1.0 unit in the case of a declared content of less than 10%

Lysine*:

15% of the declared content

Methionine**:

15% of the declared content

Cystine**:

20% of the declared content

Crude fat*

1.5 units in the case of a declared content of a minimum of 15%
10% at declared content of more than 8% (up to 15%)
0.8 unit in a case of a declared content of less than 8%

Cellulose*:

5.4 units in the case of a declared content of a minimum of 12%
45% of the declared content in a case of more than 6% (up to 12%)
2.7 units in the case of a declared content of less than 6%

Crude ash*:

3.0 units in the case of a declared content of a minimum of 10%
30% of the declared content in a case of more than 5% (up to 10%)
1.5 unit in the case of a declared content of less than 5%

Energy**:

3.0 units per 100 kg

Calcium and phosphorous¹***:

1.2 units in the case of a declared content of a minimum of 16%
7.5% of the declared content in a case of more than 12% (up to 16%)
0.9 unit in the case of a declared content of more than 6% (up to 12%)
15% of the declared content in a case of more than 1% (up to 6%)
0.15 unit in the case of a declared content of less than 1%

Sodium and magnesium**:

1.5 unit in the case of a declared content of a minimum of 15%
10% of the declared content in a case of more than 7.5% (up to 15%)
0.75 unit in the case of a declared content of more than 5% (up to 7.5%)
15% of the declared content in a case of more than 0.7% (up to 5%)
0.1 unit in the case of a declared content of less than 0.7%

* These nutrients **must** be declared in conjunction with the sale of feed mixes and will be subject to official control.

** These nutrients **may** be declared (on a voluntary basis). Where a nutrient has been voluntarily declared, it will be subject to official control.

1) Calcium: Must only be declared in a case where content exceeds 5%. Phosphorous: Must only be declared in a case where content exceeds 2%.

Appendix 3 (continued): Tolerances for feed mixes for pigs

General nutrients – maximum levels

Raw protein*:

4.0 units in the case of a declared content of a minimum of 20%
20% of the declared content in a case of more than 10% (up to 20%)
2.0 units in the case of a declared content of less than 10%

Crude fat*:

3.0 units in the case of a declared content of a minimum of 15%
20% at declared content of more than 8% (up to 15%)
1.6 units in the case of a declared content of less than 8%

Cellulose*:

1.8 units in the case of a declared content of a minimum of 12%
15% of the declared content in a case of more than 6% (up to 12%)
0.9 unit in the case of a declared content of less than 6%

Crude ash*:

1.0 unit in the case of a declared content of a minimum of 10%
10% of the declared content in a case of more than 5% (up to 10%)
0.5 unit in the case of a declared content of less than 5%

Calcium and phosphorous¹**:

3.6 units in the case of a declared content of a minimum of 16%
22.5% of the declared content in a case of more than 12% (up to 16%)
2.7 units in the case of a declared content of more than 6% (up to 12%)
45% of the declared content in a case of more than 1% (up to 6%)
0.45 unit in the case of a declared content of less than 1%

Water²**:

1.0 unit in the case of a declared content of a minimum of 10%
10% of the declared content in a case of more than 5% (up to 10%)
0.5 unit in the case of a declared content of less than 5%

Sodium and magnesium**:

4.5 units in the case of a declared content of a minimum of 15%
30% of the declared content in a case of more than 7.5% (up to 15%)
2.25 units in the case of a declared content of more than 5% (up to 7.5%)
45% of the declared content in a case of more than 0.7% (up to 5%)
0.3 unit in the case of a declared content of less than 0.7%

* These nutrients **must** be declared in conjunction with the sale of feed mixes, and will be subject to official control.

** These nutrients **may** be declared (on a voluntary basis). When a nutrient is voluntarily declared, it is subject to official control.

- 1) Calcium: Must only be declared in the case where content exceeds 5%. Phosphorous: Must only be declared in a case where content exceeds 2%.
- 2) Water must only be declared in the case where content exceeds 14%.

Appendix 4 Maximum levels of undesirable substances in feed

The Danish Plant Directorate's Regulation No.1171/2007, Appendix 10 extract

Feedstuffs		Maximum content in mg/kg (ppm) calculated on the basis of water content at 12%	
A	SUBSTANCE (ION, ELEMENT)		
1.	Arsenic	Feedstuffs excluding:	
		- phosphates	2
		- feedstuffs processed from fish or other marine animal	10
		Whole feed mixes	15
		Supplementary feed mixes excluding:	2
		- mineral feeds	4
2.	Lead	Feedstuffs excluding:	10
		- greenfeed	30
		- phosphates	15
		- dry yeast	5
		Whole feed mixes	5
		Supplementary feed mixes excluding:	10
4.	Quicksilver	- mineral feeds	15
		Feedstuffs excluding:	0.1
		- feedstuffs processed from fish or other marine animal	0.5
		Whole feed mixes	0.1
		Supplementary feed mixes	0.2
		5.	Nitrite
Whole feed mixes	15 (expressed as sodium nitrite)		
6.	Cadmium	Vegetable based feedstuffs	1
		Animal based feedstuffs	2
		Phosphates	10
		Whole feed mixes	0.5
		Mineral feed mixes	5

B. PRODUCTS

7.	Alpha toxin B1	Feedstuffs:	0.02
		Whole feed mixes for pigs and poultry (excluding young animals)	0.02
		Other whole feed mixes	0.01
		Other supplementary feed mixes	0.005
8.	Prussic acid	Feedstuffs excluding:	50
		- flaxseed	250
		- flaxseed cake	350
		- manioc and tapioca products and almond cakes	100
		Whole feed mixes	50
11.	Volatile mustard oil	Feedstuffs excluding:	100
		- rapeseed cake	4,000 (allylthiocyanat)
		Whole feed mixes excluding:	150 (allylthiocyanat)
		- whole feed mixes for poultry and pigs (excluding weaners)	500 (allylthiocyanat)
13.	Ergot of rye	All feedstuffs containing unground cereals	1000
21.	DDT (the sum of DDT, TDE and DDE expressed as DDT)	All feedstuffs, excluding	0.05
		- fats	0.5
27.	Dioxon (the sum of polychloride dibenzo-p-dioxins (PCDD) and polychloride dibenzofurans (PCDF) expressed in WHO's toxic equivalency as per WHO-TEF (toxic equivalency factors, 1997)) PCDD/F	All vegetable feeds, including vegetable oil and by-products	0.75 ng WHO-PCDD/F-TEQ/kg
		Minerals	1.0 ng WHO-PCDD/F-TEQ/kg
		Animal fat, including dairy fat and egg fat	2.0 ng WHO-PCDD/F-TEQ/kg
		Other products derived from land animals	0.75 ng WHO-PCDD/F-TEQ/kg
		Feed mixes	0.75 ng WHO-PCDD/F-TEQ/kg
		Kaoline and other 'binding, anti-caking and coagulating substances'	0.75 ng WHO-PCDD/F-TEQ/kg
		Fishoil	6 ng WHO-PCDD/F-TEQ/kg
		Fish and other aquatic animals and by products apart from fishoil	1.25 ng WHO-PCDD/F-TEQ/kg

Appendix 5 Microminerals and vitamins

Maximum content of micro minerals in whole feed for pigs:

Micromineral	Whole feed, maximum mg/kg (ppm)*
Iron - Fe	750
Iodine - J	10
Cobalt - Co	2
Copper - Cu	Until 12 weeks: 170
Copper - Cu	After 12 weeks: 25
Manganese - Mn	150
Zinc - Zn	150
Molybdenum - Mo	2.5
Selenium - Se	0.5

* The maximum amount allowed in the feed

Maximum content of vitamins:

Vitamin A Maximum 13,500 I.U. per kg whole feed for finishing pigs

Vitamin D Maximum 2,000 I.U. per kg whole feed

Appendix 6 Conditions for delivery of pigs

A pig is suitable for delivery in the following circumstances:

- Normal behaviour
- Eating and drinking as normal
- No signs of lameness are apparent and the animal puts equal pressure on all four legs
- All quarantine periods have been adhered to and the animal has not been fed in the five hours prior to loading.

A pig is unsuitable for delivery in the following circumstances:

- Body temperature above 39.5 °C
- Outbreak of flu or pleuropneumonia
- Suspected swine fever, PDNS or erysipelas
- Hernia affecting walking ability or the animal's overall well-being or leading to lesions or sores.

Tail bites or other wounds that display the following characteristics:

- Bleeding
- Effect on the overall well-being of the animal
- Exposed tendons and bones.

Handling injured animals:

Lameness: Pigs must be transferred to sick pen and treated. Pigs with chronic lameness or broken bones must be put down.

Acute hernia: Pigs with a hernia should be sent for slaughter before the problem becomes extensive. Pigs with acute hernia must be put down.

Pigs with a hernia that are not affected, i.e. have problems walking, or have lesions and sores, must be housed in a separate pen and loaded separately.

Pigs with hernia must be transported separately to the abattoir.

Tail bites: Pigs with serious tail bite injuries must be put down.

Suspected swine fever or PDNS: The vet must be called immediately – pigs must not be sent for slaughter.

Appendix 7 Guidelines for production of quality meat

1. No use of pig breeds carrying the RN⁺ gene or halothane-sensitive pig breeds.
2. Before slaughter, animals should fast a minimum of 12 hours and for no longer than 22 hours.
3. The stress level of the animals during collection, transport and at the abattoir should be kept as low as possible. This can be achieved by the following measures:
 - Avoid mixing of pigs from different pens
 - No use of electric goads
 - Ensuring that pigs calm down during lairage
 - Group stunning of the pigs as soon as possible.
4. Warm air intake during the slaughter process must be minimised.
5. The chilling process must be organised to avoid a rapid or slow chilling process:
 - Chilling tunnel: temperature: -18 - -22 °C
air exchange rate: 3-5 m/s
processing time: 70 minutes approx.
 - Equalisation rooms: temperature: 4.5 °C
air exchange rate: 0.1-0.2 m/s
room humidity: 85-95% r.h.
equalisation time: 16-20 hours
4-5 pigs per meter sliding pole
6. Once chilled, the meat temperature must be maintained and must not exceed 7 °C until any freezing of the meat takes place.
 - Before cutting, the temperature of the carcasses must be fully equalised (see 5), at a level of max. 7 °C.
7. Any compression of meat during handling and storage must be avoided.
8. Cuts of fresh meat should mature at 2-4 °C for min. 3 days calculated from the time of cutting.
9. Freezing must be carried out as quickly as possible after boning. As a minimum requirement, an average nucleus temperature of -12 °C must be obtained within 24 hours. After this time the products may be taken to a cold store.
10. The temperature in the frozen meat must be maintained at max. -18 °C until thawing.

Appendix 8 Residue surveillance in Danish pork (Slaughter pigs)

Antibiotics/chemotherapeutics ¹⁾

YEAR	TOTAL PIG SLAUGHTERINGS (m)	SAMPLES ²⁾		% OF PIGS SLAUGHTERED	NUMBER OF POSITIVE SAMPLES	% POSITIVE OF SAMPLES TAKEN
		Statutory Control	Self audit			
1998	20.4		20,509	0.09	3	0.01
1999	20.4		21,154	0.09	4	0.02
2000	20.9		20,474	0.10	3	0.02
2001	20.9	9,720	12,194	0.10	1	0.005
2002	20.5	3,783	19,943	0.11	5	0.02
2003	21.0	4,188	19,848	0.11	5	0.02
2004	21.7	1,752	19,372	0.09	1	0.005
2005	21.1	1,382	18,910	0.09	0	0.00
2006	20.3	1,356	17,956	0.09	1	0.006
2007	19.5	4,252	17,612	0.10	1	0.006
2008	19.0	1,607	22,806	0.12	2	0.008

1) Incl. blood samples tested for sulphonamides, including sulphadimidine

2) From 1 May 2001 the control of antibiotic residues in pigs is included in the approved self audit at the abattoirs

Antibiotics/chemotherapeutics excluding sulphonamides ¹⁾

YEAR	TOTAL PIG SLAUGHTERINGS (m)	SAMPLES ²⁾		% OF PIGS SLAUGHTERED	NUMBER OF POSITIVE SAMPLES	% POSITIVE OF SAMPLES TAKEN
		Statutory Control	Self audit			
1998	20.4		17,548	0.09	1	0.01
1999	20.4		18,126	0.09	3	0.02
2000	20.9		20,096	0.10	3	0.02
2001	20.9	9,339	12,194	0.10	1	0.005
2002	20.5	3,403	19,943	0.11	5	0.02
2003	21.0	3,808	19,848	0.11	5	0.02
2004	21.7	1,375	19,372	0.09	1	0.005
2005	21.1	1,002	18,910	0.09	0	0.00
2006	20.3	1,009	17,956	0.09	1	0.006
2007	19.5	3,902	17,612	0.10	1	0.006
2008	19.0	1,307	22,806	0.12	2	0.008
2009	19.0	–	21,686	0.11	1	0.005

1) Excl. blood samples tested for sulphonamides

2) From 1 May 2001 the control of antibiotic residues in pigs is included in the approved self audit at the abattoirs.

Appendix 8 (continued): Residue Surveillance in Danish Pork

Sulphonamides, incl. sulphadimidine ¹⁾

YEAR	TOTAL PIG SLAUGHTERINGS (m)	SAMPLES		NUMBER OF POSITIVE SAMPLES	% POSITIVE OF SAMPLES TAKEN
		Number Taken	% of pigs slaughtered		
1998	20.4	2,961	0.02	2	0.07
1999	20.4	3,028	0.02	1	0.03
2000	20.9	380	0.002	0	–
2001	20.9	381	0.002	0	–
2002	20.5	380	0.002	0	–
2003	21.0	380	0.002	0	–
2004	21.7	377	0.002	0	–
2005	21.1	380	0.002	0	–
2006	20.3	347	0.002	0	–
2007	19.5	350	0.002	0	–
2008	19.0	300	0.002	0	–

1) Blood samples collected from finishing pigs, sows and boars.

Hormones, β -agonists, sedatives and β -blocking substances, including endo- and ectoparasitic substances ^{*)}

YEAR	TOTAL PIG SLAUGHTERINGS (m)	SAMPLES		NUMBER OF POSITIVE SAMPLES
		Number Taken	% of pigs slaughtered	
1998	20.4	4,806	0.02	0
1999	20.4	4,628	0.02	0
2000	20.9	6,090	0.03	0
2001	20.9	5,792	0.03	0
2002	20.5	4,521	0.02	0
2003	21.0	5,525	0.03	0
2004	21.7	5,536	0.03	0
2005	21.1	6,364	0.03	0
2006	20.3	6,386	0.03	0
2007	19.5	4,887	0.03	0
2008	19.0	6,101	0.03	0

*) The group of substances A1, A2, A3, A4, A5, A6 and B2a, B2c and B2d

Appendix 8 (continued): Residue Surveillance in Danish Pork

Pesticides and PCB's

YEAR	TOTAL PIG SLAUGHTERINGS (m)	SAMPLES		NUMBER OF POSITIVE SAMPLES ABOVE THE MAX. RESIDUE LIMIT*
		Number Taken	% of pigs slaughtered	
1998	20.4	207	0.001	0
1999	20.4	1,015	0.004	0
2000	20.9	341	0.002	0
2001	20.9	327	0.002	0
2002	20.5	249	0.001	0
2003	21.0	219	0.001	0
2004	21.7	262	0.001	0
2005	21.1	262	0.001	0
2006	20.3	252	0.001	0
2007	19.5	250	0.001	0
2008	19.0	264	0.001	0

*) Detection of residues at levels below the maximum residue limit presents no risk to human health

Heavy metals

YEAR	TOTAL PIG SLAUGHTERINGS (m)	SAMPLES		NUMBER OF POSITIVE SAMPLES ABOVE THE MAX. RESIDUE LIMIT*
		Number Taken	% of pigs slaughtered	
1998	20.4	0	–	–
1999	20.4	0	–	–
2000	20.9	1	–	0
2001	20.9	5	–	0
2002	20.5	5	–	0
2003	21.0	10	–	0
2004	21.7	102	<0.001	0
2005	21.1	55	<0.001	0
2006	20.3	61	<0.001	0
2007	19.5	61	<0.001	0
2008	19.0	60	<0.001	0

*) Detection of residues at levels below the maximum residue limit presents no risk to human health.

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