

Danish salmonella control scheme

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The Danish salmonella control scheme was the first plan introduced to control the occurrence of salmonella in countries with intensive pig production. The plan was implemented 10 years ago and has been revised four times during its existence in order to optimise the effect and improve cost-benefit. The Danish control scheme combines public and industrial controls in as much as the Danish authorities set up its framework and overall objectives, and the pig meat industry is responsible for the implementation of the control scheme.

The Danish pig meat industry has invested DKK900m in total corresponding to about US\$143m, and Danish authorities have financed just under DKK100m corresponding to approximately US\$16m.

The control scheme covers the entire chain from stable to table, and results generated on feeds, breeding, sow and slaughter pig herds and on fresh meat are released currently.

Controls of pig herds are based on serological and bacteriological testing. The pig meat industry has imposed a penalty system on herds with high levels of salmonella to motivate herd owners to reduce the prevalence of salmonella.

Level	1	2	3
Percentage	96.1	2.9	1.0

Table 1. Distribution of salmonella level 2 and 3 in slaughter pig herds in Denmark, September 2005.

Slaughterhouses will be requested to use a more rigorous surveillance if the salmonella prevalence is >2.2% in fresh meat and to work out a control plan to demonstrate improvements within a six month period. The control scheme works well and is known on most of the 130 markets to which Denmark is exporting pig meat. The effect of the control scheme is a significant fall in the annual prevalence of salmonella in pig meat from 4 to 1.2% and a fall in human infections in Denmark that can be related to pork from approximately 1,100 to 150.

Despite Denmark's limited size of just 44,000km², the country produced 22.8million slaughter pigs in 2004. Denmark has approximately 10,000 pig producers, of whom 95% are members of the 110 year

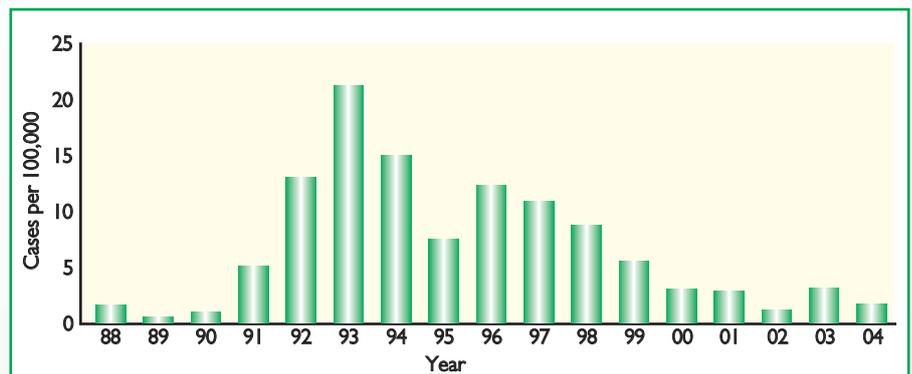


Fig. 1. Human salmonellosis attributable to pork in Denmark, 1988-2004. Cases per 100,000 inhabitants.

old nationwide producer cooperative, the Danish Bacon and Meat Council.

With a population of 5.3 million inhabitants, domestic consumption accounts for less than 15% of the produced pork, whereas the remaining 85% is exported worldwide.

Food safety standards have been a matter of high political priority during the most recent decade in Denmark and it is, therefore, a prerequisite for the pig industry to remain acceptable among the Danes. Furthermore, food safety is a prerequisite for export of pork. The salmonella programme is described briefly in this article and the food safety standards evaluated.

Salmonella

In 1993, the Danish Ministry of Food, Agriculture and Fisheries and the Danish Bacon and Meat Council initiated an ambitious programme to reduce pork as an important source of human salmonellosis. In

the beginning of the 1990s, pork was recognised as an increasingly important source of human salmonellosis in Denmark.

Estimates from the Danish Zoonosis Centre show that the total number of human salmonella cases in Denmark has fallen by more than 65% since 1997. The number of incidents peaked in 1997 when 5,000 people were taken ill compared with around 1,500 cases in 2004.

The main sources of salmonella infections are food related, both domestically produced and imported food, but also travels abroad are major sources.

The cases associated with pork peaked in 1993, and following this a number of initiatives to reduce salmonella in the pig industry were implemented. Consequently, pork has steadily declined as a source of human salmonellosis since 1996.

Results from 2004 show an incidence rate of 2.6 cases per 100,000 inhabitants in Denmark equal to 142 human cases related to pork (Fig. 1).

Continued on page 9

Table 2. Prevalence of Salmonella spp. in Danish pork, 1996-2004. The prevalence of salmonella in the years 1996-2000 was determined by culturing different pork cuts, whereas the prevalence in 2001-2004 was determined by culturing swabs from 300cm² of a carcass. Numbers marked with * are calculated prevalence for direct comparison (Annual Report on Zoonoses in Denmark).

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004
%	1.2	1.1	1.2	0.9	0.7	0.65*	0.7*	0.7*	0.7*
Positive samples						1.3	1.4	1.4	1.3

Continued from page 7

The Danish Salmonella Control Programme for pigs operates at all stages of the production chain and has applied nationally since 1995. It is adjusted nearly every year in order to optimise the cost effectiveness as the pig industry develops swiftly.

The level of salmonella is controlled at various stages:

- Feedstuffs.
- Breeder and multiplier herds.
- Weaner producing herds.
- Slaughter pig herds with a production of more than 200 slaughter pigs per year.
- At the slaughterhouse, including special hygienic slaughter of highly infected herds.

Feedstuffs

The national programme requires mandatory salmonella testing in all plants that produce animal feed. The test involves microbiological analyses of compounded feedstuffs as well as the collection of samples from critical control points during the production. Compounded feedstuffs are heat treated at 81°C to eliminate salmonella bacteria.

A new risk based strategy was introduced in 2003. The bacteriological sampling procedure focuses on controlling the processing of feedstuffs and on feedstuffs with a known high salmonella risk, for example soy.

Breeders and multipliers

Each month, all herds are blood sampled and examined for salmonella antibodies. Based on the level of antibodies, a salmonella index is calculated. If the index is 5 or above 5, pen faecal samples must be taken and examined for the presence of Salmonella spp., and the farmer must inform all buyers about the presence of salmonella on the farm.

Weaner producers

If a sow herd owner sells weaners to a slaughter pig herd in salmonella level 2 or 3, pen faecal samples must be taken in the sow herd and examined for the presence of Salmonella spp.

Slaughter pig herds

All finishing herds producing >200 slaughter pigs per year are tested for salmonella antibodies routinely. The testing is mandatory and paid by the slaughterhouses and, thereby, the farmers.

Herds in level 1 with a slaughter pig index 0 and at least 10 negative meat juice samples in the most recent six months are assigned to a special sampling scheme. These herds have shown a very low and stable salmonella prevalence over time. Without jeopardising

Serotype	%
S. typhimurium	40.0
S. derby	19.0
S. infantis	7.0
S. livingstone	0.5
Exotic serotypes (n= 23)	12.0
Rough isolates	19.0
Non typable	0.5

Table 3. Distribution of salmonella serotypes in Danish pork in 2004.

dising food safety, it is possible to reduce the number of samples and, consequently, these herds have only one sample taken every month.

However, if the sample is positive, the herd will immediately be transferred to the ordinary sampling scheme in which 5-8 samples are taken every month depending on herd size.

In total, samples are collected from 400,000 slaughter pigs on an annual basis. The samples are collected at the slaughter plant after the kill. A small piece of meat is taken from one of three well defined muscles and put into a container. The container is frozen at minus 20°C overnight and shipped to the laboratory for analyses. On arrival at the laboratory, the meat will be thawed, and meat juice is passively released into a container. The meat juice contains antibodies and may be used in serological tests as prediluted serum.

Each month, the herds are assigned to three levels according to the proportion of

the salmonella serotype. This is done by bacteriological examination of 20 pen faecal samples randomly selected from the different pens in the herd.

Additionally, the farmer must inform the authorities from whom he has received the weaners during the most recent six months. Samples must also be collected in these herds for salmonella testing, and the pig producer pays for the examination.

Special hygienic slaughter

Herds assigned to level 3 have to be slaughtered under special hygienic precautions. This is done at special slaughter plants at the end of the day to prevent cross-contamination with other carcasses. Carcasses from level 3 herds also have to be heat treated or subjected to other special treatment.

Slaughter plants may also test carcasses free randomly on the basis of guidelines issued by the Danish Veterinary and Food Administration.

Financial penalties

The nationwide producer cooperative, the Danish Bacon and Meat Council, has implemented a strict salmonella penalty system. The purpose is to improve the salmonella control as much as possible in herds with positive samples. In practice, an intervention

Activity	Farmers	Slaughterhouses	DBMC	Veterinary authorities
Breeding herds	143			
Sow herds	413			
Slaughter pig herds	762			
Meat juice analyses		635	1,000	
Carcase swabs		349		
Special slaughter				
Level 3 herds		1,111		
Administration		793	476	
Sub total	1,318	2,095	1,793	476
Total		5,682		

Table 4. Expenses of the Danish salmonella surveillance and control programme ++2004. All costs are in thousand US\$.

seropositive samples during the most recent three months. Level 1 herds are herds with no or few seropositive samples, level 2 herds are herds with a moderate number of seropositive samples, while level 3 herds are herds with a high proportion of seropositive samples. The serological results from the most recent three months are expressed as the salmonella index. Level 1 herds have an index from 0-39.9, level 2 herds from 40.0-69.9, and level 3 herds from 70.0 and upwards. The distribution of slaughter pig herds in levels 1, 2 and 3 in September 2005 is shown in Table 1.

Level 2 and 3 herds

The veterinary authorities require that faecal samples should be taken in order to identify

plan in order to reduce the prevalence of salmonella carries this out. The producer and his advisers work out a detailed plan.

The level of the financial penalty corresponds to the level to which the herd is assigned:

- Level 1 = 0%.
- Level 2 = 2% all months while in level 2.
- Level 3 = 4, 6 and 8% depending on the number of months in level 3.

Statutory information

Pig producers must inform buyers of live pigs about the salmonella status of the farm.

The serological index from the most recent three months as well as the results of any bacteriological salmonella examination

Continued on page 11

Continued from page 9
of the farm during the most recent six
months must be given.

Surveillance in fresh pork

Since 1993, fresh pork has been surveyed for *Salmonella* spp. at the slaughterhouses. The prevalence has declined from 3.5% in 1993 to 0.7% in 2000 (Table 2) and has remained at a similar low level since then.

From 1993 to 2000, the surveillance was conducted by bacteriological examination of different pork cuts. Approximately 28,000 pork cuts were tested on an annual basis. A new method of salmonella testing of carcasses was introduced in 2001.

Five carcasses per slaughter day are swabbed on three defined areas (the sternum, the hind leg near the tail and the jowl) at 100cm² for each sample.

The swabbing areas were originally defined by the USDA, and are currently used in the USA as the national salmonella monitoring method on pig carcasses.

This method is twice as sensitive as the one previously used, and consequently the apparent salmonella prevalence in Danish pork doubled.

Naturally, this should only be regarded as an effect of the improved test sensitivity, and not as increased salmonella prevalence as such.

In general, 10-15 different serotypes are isolated from Danish pork. However, *S. typhimurium* constitutes approximately 50% of the isolates (Table 3).

The level of *Salmonella typhimurium* is very low in Danish pig meat (0.002%). If a slaughterhouse establishment has a salmonella prevalence at 2.2% or above in four consecutive months, an Intensified

Control Programme will be implemented immediately. If the establishment does not decrease the prevalence on the basis of the Intensified Control Programme, the veterinary authorities may enforce additional hygiene measures on the slaughterhouse.

Hot water decontamination

Slaughter pigs infected with multiresistant *S. typhimurium* DT104 and slaughter pig index 20 will either be slaughtered under special hygienic conditions as with Level 3 herds that are subsequently heat treated, or they will be decontaminated with hot water.

The carcasses will be decontaminated after evisceration of the organs.

The carcass is showered with 80°C hot water for 14-16 seconds, which produces a significant reduction (approximately 1.0 log, tunnel cooling 0.7 log) in the bacterial count on the surface. Five carcasses from each batch are tested to ensure that the process is effective.

If *Salmonella* spp. is not detected, it will be possible to use the batch for fresh consumption.

Laboratory requirements

The serological testing for salmonella antibodies is only carried out at one laboratory: Danish Institute for Food and Veterinary Research, in order to ensure a high cost effectiveness of the analyses.

Bacteriological examinations of pen faecal samples for salmonella are currently done at three accredited laboratories – Danish Institute for Veterinary Research, the veterinary laboratory of the Danish Bacon and Meat Council or at Steins.

The bacteriological examinations of carcass swabs are mainly done at four different accredited slaughter plant laboratories under the Danish Bacon and Meat Council.

Programme financing

In accordance with Danish regulations, it is mandatory to test for salmonella. Additionally, the Danish Bacon and Meat Council has set up further requirements that members of the cooperative must meet.

A National Salmonella Steering Committee consisting of the pig industry, the veterinary authorities, national research institutes, and breeding companies follows and evaluates the programme closely.

The Danish Bacon and Meat Council chairs the committee, and has the direct responsibility for the daily administration.

The pig industry pays more than 90% of the costs of the entire programme. In 2004, the total expenses of the salmonella programme was calculated to be approximately US\$5.7m corresponding to US\$0.24 per slaughter pig produced in Denmark (see Table 4).

Conclusion

Food safety standards have been given high political priority during the most recent decade in Denmark and are preconditional for the pig industry to remain acceptable among the Danes.

The Danish salmonella programme is the first salmonella programme in a major pig producing country to focus on both pre-harvest, harvest and post-harvest levels. The programme is responsible for a significant reduction in the level of salmonella in pig herds, in pork and, most importantly, among humans in Denmark.

Even though the expenses have been, and still remain high, the Danish pig industry fully supports the salmonella programme. The low level of salmonella in Danish pork makes pig production acceptable among Danish politicians and is in line with the export slogan for Danish pork 'safe and clean'.

The Danish salmonella programme is a model for similar salmonella control programmes currently being implemented in Germany, the Netherlands, Belgium, Ireland and the UK. ■