Session 5 Microbiology and hygiene

L 1 AN INDUSTRIAL MEAT PRODUCTION BASED ON MODERN MEAT INSPECTION PROCEDURES - A HUMAN PATHOGEN FREE (HPF) MEAT CONCEPT

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Background

In March 2001, during the conference "Food Chain 2001" in Uppsala, Sweden, Dr. Gro Harlem Brundtland, Director-General of The World Health Organization stated: "We need to accept that the systems we use in Europe to ensure food safety are not as good as we have come to believe. To improve these systems and re-establish consumer confidence, we must reassess them all the way from the farm to the table". In this context, meat inspection practices presently employed in the member states of the European Union (EU) and most of the world, have their origins from the end of the nineteenth century and have to be re-considered and adjusted to the hazards of today.

Occurrence of human pathogens at herd level and significance for slaughtering and dressing, meat inspection practices and the consumers

The problems with *Salmonella* related to consumers as results of deficient production systems and meat inspection procedures are illustrated in Table 1 and indicate the food safety problems in Europe today. This table shows the frequency of inhabitants suffering from salmonellosis infected domestically. Countries like Norway and Sweden have a low frequency of domestic human *Salmonella* infection. Animals, particularly chicken and pigs (not shown) have high *Salmonella* carrier rates in countries with high levels of domestic human infection in contrast to the frequencies in countries like Norway and Sweden with low domestic human infection levels. This is explained in Figure 1 and Table 2. Figure 1 reveals that the frequency of salmonellosis among people in Norway is closely linked to the frequency of charter travel (often to Mediterranean countries with a high carrier rate at herd level), while Table 2 shows the shortcomings of the meat inspection to protect consumers by their traditional procedures. However, this table also points to the possibilities for farmers and the meat industry to invest in measures which may protect the consumers.

The significance of HPF herds for the meat industry, meat inspection and the consumers are important and crucial. Again, *Salmonella* is used as an example (Berends et al., 1997): A live animal carrying *Salmonella* spp. are 3-4 times more likely to end up as a *Salmonella* positive carcass than *Salmonella*-free animals. Currently, 70% of all carcass contamination is caused by animals carrying the organism while the remaining 30% are caused by cross contamination from animal carriers slaughtered concurrently.

With respect to the contamination with *Salmonella* spp., dirty polishing machines (Odds ratio 6) and particularly errors during evisceration (Odds ratio 11) are the major important risk factors. An estimated 5-15% of all carcass contamination with *Salmonella* spp. occurs during polishing after singeing. The remainder resulting from current evisceration practices (55-90%) and, to a lesser extent, further dressing and meat inspection procedures (5-35%). However, it can also be concluded that if only *Salmonella*-free pigs were produced, the consumer could buy virtually *Salmonella*-free pork.

Table 1. Domestic *Salmonella* infections in some countries and carrier rates of chicken (Barrel, 1987; Engvall and Andersson, 1993; Giessen et al., 1991; National Institute of Public Health, 2000)

Country	Domestic infection (% of total persons diagnosed)	*Salmonella* in chicken (% of total tested)
England/Wales	87	80
The Netherlands	85	94
Denmark	80	50
Sweden	15	<1
Norway	20	<1

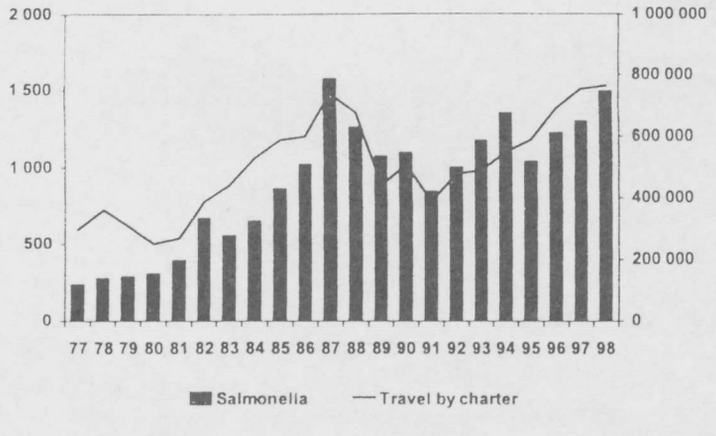

Figure 1. Frequency of human salmonellosis in Norway and numbers of inhabitants travelling by charter the same period (National Institute of Public Health, 2000).

Table 2. Infectious agents and animal sources of significance in food production with indications of points in the production chain where preventive measures may be introduced, and with what effects

Agent (source)	Possibilities for preventive action/reduction in/at:				
	Herd/flock	Meat inspection	Slaughter	Cutting	Processing
Salmonella (poultry/pigs)	+++	-	++	-	+
Campylobacter (poultry)	+++	-	-	-	+
E. coli O157 (cattle)	+?	-	++	-	+
Y. enterocolitica (pigs)	+++	-	++	-	+
Toxoplasma (sheep)	+	-	-	-	+
Trichinella (pigs)	++	++	-	-	+

(+++ = great effect, ++ = good effect, + = effect, somewhat limited, - = probably of little effect)

The significance of HACCP and risk assessment of the contamination during slaughter

There is general consensus that scientifically validated, quantitative assessments of actual public health risks are a prerequisite for any sound modernisation of current meat inspection procedures. The use of highly structured and very elaborate descriptive epidemiological models covering the entire period from stable to table can be considered a promising solution. Health risks can be quantified by means of incidence rates and the influence of risk factors by means of odds ratios and (population) attributable fractions (Berends et al., 1996).

It is not possible to sort out pigs contaminated with human pathogenic agents by the visual compulsory post-mortem meat inspection procedures. Pig slaughter is an open process with many possibilities for contaminating the pig carcass with human pathogenic bacteria, and it does not comprise any point where hazards are completely eliminated (Borch et al., 1996). In conclusion, the major sources of contamination during slaughter are animal-related, such as faecal and pharyngeal, and environmental. HACCP and GMP in slaughter must be focused on limiting this spread (Borch et al., 1996; Berends et al., 1996).

Meat inspection procedures concerning the head also seem to represent a cross-contamination risk: Incision of the submandibular lymph nodes is a compulsory procedure according to the EU regulations (European Commission, 1995). This may, however, result in bacteria being transmitted from the head/medial neck to other parts of the carcass by the knives and hands of the meat inspection personnel (Nesbakken, 1988). In view of the fact that the incidence of tuberculosis in pigs and humans has been reduced to a very low level in many parts of the world, it may be possible to re-consider regulations that require incision of the submandibular lymph nodes.

Risk-based meat inspection and serological tests for human pathogens

The major microbial foodborne hazards associated with pork are *Salmonella, Yersinia enterocolitica* and *Toxoplasma gondii*; only limited data is available on enterohaemorrhagic *E. coli*. *Trichinella spiralis* is a threat to consumers in countries where wildlife close to farms are carriers. There is no evidence to support the role of mycobacteriosis as a foodborne zoonosis from animals in most Western industrialised countries today. Inspection and incision to disclose caseous lymphadenopathy implies a strong potential of cross contamination with *Yersinia enterocolitica* and *Salmonella*. A change from a traditional post mortem meat inspection procedure to an entirely visually orientated ante-mortem inspection to disclose animals suffering from severe animal diseases, and serological tests of human pathogenic agents based on blood samples are probably the issues in a modern dynamic meat inspection based on risk assessment (Table 3). Results of such tests will determine the fates of the animals. The indirect benefit of such a meat inspection system is the fact that these procedures will entail less labour, and the scarce control resources may be allocated to hygienic surveillance programmes and wider risk assessment strategies.

Serological tests for human pathogens and the consequences for procedures at the slaughterhouse and in the meat industry

Serological tests may be used as tools for control of human pathogenic agents. The consequences for the slaughterhouse and the meat industry are identification and categorisation of herds, animals and products. Accordingly, traceability and new logistic procedures are needed. Only HPF herds should be in contact during transport and lairage and slaughtered at the same time. Carrier herds of pathogenic agents should be separated from HPF herds and slaughtered separated in time. Adjustment of payment to the farmer (incentive bonus to carrier-free herds) may be used to encourage farmers to join herd sanitation programmes (Skjerve et al., 1998). Meat originating from HPF herds may be used as raw material for fresh meat, while meat from positive herds should be used for heat-treated products. Carcasses from *Toxoplasma* positive animals should be frozen before cutting and processing to ensure meat safety.

Table 3. Examples of agents that may be detected by serological testing of pigs at herd level

Agent	Examples – References
Salmonella spp.	Nielsen et al. (1995)
Taenia solium	D'Souza and Hafeez (1999)
Toxoplasma gondii	Van Knapen et al. (1982)
Trichinella spiralis	Van Knapen et al. (1984)
Yersinia enterocolitica	Nielsen et al. (1996)

Safety first

Doubtless, the future for the meat industry is to produce meat according to standards which will ensure meat products free from human pathogenic agents. May be it is possible to have a segregated meat market with cheap meat which may contain *Campylobacter, Salmonella, E. coli* O157, *Toxoplasma* or other pathogenic agents, while the exclusive meat does not. The experience from the automobile industry has shown that this kind of segregation is possible only for a certain period of time. It is no longer possible to sell unsafe new cars in Western industrialised countries. A few years ago some people were willing to pay extra for the high safety level of cars like a Mercedes, Volvo and SAAB. However, nowadays, all leading car companies are competing to produce cars according to specific safety standards. This year the safest car is not a Mercedes, Volvo or a SAAB, but a middle class car produced by Renault. In addition, the focus on meat hazards during the BSE and other meat scandals will also lead the consumers and their organisations to increased alertness for other pathogens in meat. Presumably, the future market survivors in the European meat market are producers which can guarantee a meat product free from human pathogenic agents. As an example, a company in Denmark is already marketing *Salmonella* and *Campylobacter* free chicken.

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