Public health and pork: pre-harvest food safety and slaughter perspectives

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Summary
Operating conditions for the food industry in general and pork production in particular are changing. The safety and quality of food are attracting increasing concern from the consumer, especially in industrialised countries. This paper describes the impact on the swine industry and on the veterinary profession of the ‘farm-to-table’ concept and the implementation of hazard analysis and critical control point plans throughout the food production chain.

Keywords

Introduction
Pork is the most popular meat consumed in the world today (44% of world meat protein consumption is derived from pork and pork products) and the demand for pork is increasing globally, due to both continuous population expansion and the improvement of living standards in many developing countries (7). However, two new factors are making a growing impact on food production: the liberalisation of world trade, and the increasing demands made by consumers in industrialised countries that food be both economical and healthy, tasty, safe and sound in respect to animal welfare and the environment. These two elements are changing hitherto quantity-oriented food production, which was often subsidised and which guaranteed the nutrient supply for a nation, into an international quality-oriented food market, where commodities, production areas, production chains and brands compete for custom (6, 9, 10, 24). The competitiveness of meat production will become more dependent on the reliability of the safety and the quality of the meat than on quantity and prices (7).

In contrast to the quantity-oriented markets, where producers can always sell any amount of produce, quality-oriented markets are consumer-driven. Thus, the influence of consumer demands, together with the steady increase of national and international food safety and public health standards, mean that the meat industry and allied industries, advisers and consultants, such as food animal veterinarians, are facing substantial changes (6, 24, 27), which will present both challenge and opportunity for all involved in the production process.

The need to improve food safety
In a number of countries, the implementation of regulations imposing consistent mandatory meat inspection, together with improvements in hygiene standards during slaughter, meat processing, storage and distribution has led to a remarkable decline of meat-related foodborne zoonoses. However, although meat inspection and food hygiene have been regarded as sufficient to guarantee safe pork for almost 100 years, new approaches to food safety and pork quality are becoming necessary (1, 6, 7, 9, 10, 12, 15, 24, 27). There are five major reasons for this need, as follows: the continued occurrence of deaths from foodborne disease, the increase in drug-resistant pathogens, the exploitation of food safety issues in trade and marketing, consumer demands and the characteristics of emerging foodborne pathogens.
Deaths from foodborne disease

In spite of recognised achievements in making food safer over the decades, deaths due to foodborne disease in humans still occur (9,000 deaths per year in the United States of America [USA]) (1). Furthermore, consumer confidence in food safety is decreasing (6). Despite unprecedented levels of safety, the public perception is that there are more risks to human health than ever before. This general recognition is highly supported by the media. Moreover, the urban consumer does not differentiate between commodities or diseases. Consequently, reports on bovine spongiform encephalopathy and Escherichia coli O157:H7 not only have an adverse impact on beef, but also on meat in general. Concerns with food safety in meat focus mainly on pathogens, antimicrobial and chemical residues, and hormones (6, 8, 9, 10, 12, 24).

Drug-resistant pathogens

Modern agricultural practices contribute to the increased occurrence of drug-resistant pathogens in humans (6) and thus are frequently criticised by medical and public health groups and consequently by the public. The latest and most serious attack is that of the Director General of the World Health Organisation (WHO), who stated in his Word Health Report 1996: ‘Making matters worse are modern types of food production. Antimicrobials are used in meat production to increase growth, but not usually in sufficient amounts to kill microbes. Drug-resistant bacteria are then passed through the food chain to the consumer’ (26).

Food safety issues

Food safety issues can easily become non-tariff trade barriers and are increasingly used as marketing tools, both nationally and internationally (6, 7, 9, 24, 27). On the national scale, advertisements for meat use food safety concerns with increasing frequency. For example, the grocery chain ‘Whole Foods Market’ in several major cities of the USA claims that ‘Our fresh meat and meat products come from animals raised naturally without hormones and antibiotics.’ Such statements create new consumer demands and increase the distrust in meat which has no safety or high-quality ‘label’. On an international scale, trade barriers which prevent national meat industries from gaining access to international markets are increasingly based on food safety concerns. These barriers require counter-measures which are equally based on safety factors: e.g., the Danish Salmonella control programme is successfully used throughout the Danish pork industry to increase pork exports from Denmark (22).

Consumer demands

Consumer demands are becoming more focused on fresh and naturally raised (organic) products (15). This return to ‘farm market produce’ results in the increasing consumption of food which is less processed than branded products which have undergone several processing procedures (cleaning, food additives such as preservatives, canning, packaging, etc.) prior to marketing. The fresher or more organic the food, the more the consumer depends on the absence of pathogens and contaminants in, or on, the raw material.

Emerging pathogens

The traditional mandatory meat inspection is still indispensable, but this process is unable to control and prevent the emerging foodborne pathogens which pose risks to human health today (6, 9, 10). In the past, classical zoonoses, such as tuberculosis and brucellosis, caused clinical diseases which could be recognised at farm level and lesions which could be observed during meat inspection at slaughter. The emerging pathogens of today, such as Salmonella, Toxoplasma, Trichinella, Campylobacter and Yersinia, are only detectable through targeted monitoring systems, as they cause neither clinical symptoms in affected animals nor lesions which could be helpful when examining contaminated carcasses.

The pre-harvest food safety approach

The majority of the real and perceived reasons for the increased concerns with the safety and quality of meat, as outlined above, apply to the pre-harvest area of the food production chain (1, 6, 7, 9, 10, 12, 15, 24, 26). Food safety measures practised after slaughter (inspection, removal of carcasses unfit for human consumption) do contribute to consumer protection, but do not prevent the major safety-related defects in the ‘interim product’ slaughter pig, i.e. they are only quality checking at the end of the on-farm production phase.

Quality checks and quality assurance

Quality checking was one of the first practices used to cope with the higher quality standards. The need to produce and sell high-quality products and to increase the efficiency of the production process simultaneously, however, has led to the development of quality assurance systems to be operated throughout the production chain. The difference between quality checks and quality assurance is explained below.

Quality checking is the evaluation of a final product prior to marketing. The evaluation is based on quality checks at the end of the production chain which class products in categories such as ‘high quality’, ‘regular quality’, ‘low quality’ and ‘non-marketable’. Since there is no way to correct production failures or upgrade the quality of the final product, low-quality products can only be sold at lower prices and the non-marketable products have to be discarded, despite having cost as much to produce as the high and regular quality products. Thus, quality checking has only a limited potential to increase the quality and efficiency of a multi-step production procedure.
Quality assurance, in contrast to quality checking, is the implementation of quality checks and procedures to correct immediately any failure or mistake which could reduce the quality of the interim products at every production step. To plan and achieve the desired high quality of the final product, a food producer should employ:

- standard operating procedures (SOP) which guarantee the desired quality of the interim products at every phase of production;
- good manufacturing practice (GMP) to ensure that the entire production chain is following a written description (handbook) of all SOPs;
- total quality management (TQM), which is the managerial approach to long-term success through customer satisfaction, and is based on the participation of all members of an organisation (suppliers included) in improving processes, products, services and the working culture.

Examples for quality assurance versus quality control in the area of food safety include the implementation of residue-avoiding production procedures at farm level (quality assurance) in contrast to the testing of carcasses for residues (quality control), or the implementation of on- and off-farm salmonella-reducing measures as standard operating procedures (quality assurance) as opposed to the testing of meat products for salmonella prior to marketing and consumption (quality control).

Hazard analysis and critical control point systems

In food production, where the safety of the food produced has ultimate priority in the framework of quality, the hazard analysis and critical control point (HACCP) system is an internationally recognised system to ensure safe food production by emphasising preventive measures to avoid food safety problems (9, 16, 27). HACCP combines common sense with an evaluation of risks to identify the points along the food production chain, where possible hazards may occur, and then strict management and monitoring of these points to ensure the process is in control. The HACCP system has three components, as follows (15):

a) The identification of hazards, and the determination of the severity of the hazard and risks: these are risks associated with growing, harvesting, processing, distributing, preparing and/or using a raw material or food product. Hazard usually means the contamination, growth or survival of micro-organisms related to food safety or spoilage, but may also include dangerous chemical contaminants or foreign objects (glass or metal fragments).

b) The determination of critical control points required to control the hazard: a critical control point (CCP) is a location, practice, procedure or process which can be used to minimise or prevent unacceptable contamination, survival or growth of foodborne pathogens or spoilage organisms, or introduction of unwanted chemicals or foreign objects.

c) Establishment and implementation of monitoring procedures to determine that each CCP is under control: monitoring systems must be able to determine effectively whether a CCP is under control or not. In the latter case, corrective action must be defined and used.

Risk is the estimate of the likelihood that the hazard will occur, and the potential impact if that risk does occur. Use of risk assessment helps identify CCPs.

Before developing an HACCP plan for a production procedure, the establishment of SOPs and GMPs is indispensable. Only the combination of these principles provides the opportunity to verify correctness and standard. Verification is the procedure which provides the guarantee to the consumer that the product is indeed of the quality claimed, and that the product has been produced in accordance with a procedure based on specific, documented GMP and HACCP principles. The verification is performed by accredited independent agencies, bodies or companies.

Consequently, the traditional mandatory meat inspection and the classical post-harvest food safety measures have limited potential to further improve the safety and quality of meat (6). Therefore, additional measures must be taken. Pre-harvest food safety programmes implementing the rules of GMP and the HACCP concept at farm level from breeding to the slaughterhouse need to be added to the existing harvest and post-harvest HACCP programmes (12, 15, 24, 27). Quality assurance systems throughout the entire food production chain should be the precondition for any certification procedure. Government food safety programmes and market-driven food safety/quality programmes must be co-ordinated.

Table I reflects the latest knowledge on the relative incidence of foodborne diseases in the USA (1, 6, 8, 9, 10, 12, 15, 24, 27) and the pork-related (12) risks to public health.

Pre-harvest intervention measures for pork production

The potential impact of pre-harvest food safety measures based on the HACCP concept obviously differs depending on the nature of the defect or pathogen addressed. There are different areas in which the defect or pathogen enters the food production chain and the potential for reducing the risk in question by proper handling and/or cooking prior to consumption also varies. Where residues in the product are concerned, residue avoidance programmes are the only opportunity for prevention, since there is no pre-consumption procedure which reduces the residue-associated risks to public health. In contrast, proper handling and freezing and/or cooking of the final product reduces the risks
The role of the pork producer is changing from solely raising pigs to being an indispensable part of the pork production chain: the producer supplies the product which is the basis for the delivery of a wholesome, safe and high-quality food product. From focusing on the treatment of diseased animals and subsequently on herd health and productivity, the swine practitioner will change to focus on assisting the pork producer by providing slaughter pigs with quality properties which meet the demands of slaughterhouses and meat-processors, wholesalers, retailers and finally the consumer. Along with consistent herd health management, the food animal practitioner will become increasingly involved in on-farm pathogen control and on-farm residue avoidance programmes, monitoring systems and verification procedures as demonstrated in Figure 1.

Measures to increase consumer confidence

To obtain a reliable decrease in the incidence of foodborne health risks and to improve consumer confidence in food of animal origin, pre-harvest food safety programmes should include the following three elements:

- Implementation of food safety specific GMP and HACCP programmes at the farm level aiming at reducing foodborne risks to public health.
- Implementation of monitoring and surveillance programmes at slaughter to determine the frequency of the introduction of foodborne health risks into the food chain and identify the farms of origin, and mechanisms to develop incentives for the farming community to reduce these risks. This element is, as a rule, the 'trigger' and 'modulator' of any pre-harvest food safety programme.
- Implementation of a certification procedure involving independent agencies and people, such as accredited veterinarians and quality consultants.

The implications of pre-harvest food safety

The table below provides risk rankings for 12 of the more important foodborne pathogens associated with pork. These rankings are based on recent risk assessments, and substantial research into the economic and public health impacts of these pathogens. In terms of public health, this table highlights that Salmonella spp. remains the most important pathogen where pork is concerned, followed by Campylobacter jejuni and Listeria monocytogenes. The data in the table indicate that pre-harvest risk-reduction programmes are needed to prevent the contamination of the carcass due to pathogens, but pre-harvest risk-reduction programmes can either prevent the contamination of the carcass (Trichinella and Toxoplasma) or contribute significantly to minimising the pathogen-associated risks (Salmonella, Campylobacter, Yersinia, Listeria).

Therefore, the targets for intervention measures in the pork production chain should be prioritised as follows:

- a) On-farm residue avoidance programmes with consistent record keeping, proper drug use, storage and extended withdrawal times. An overall reduction of antimicrobial substances used in agriculture both for medical and production purposes is necessary (5, 9, 16, 23, 26). Off-farm residue programmes which incorporate GMP and HACCP principles in the supplying feed mills to prevent cross-contamination and proper labelling should also be implemented.

- b) On- and off-farm programmes to develop Trichinella- and Toxoplasma-free herds, regions, areas and countries (3, 14, 17, 18, 24) with full co-operation between packers, producers, veterinary officers and practitioners, and epidemiologists.

- c) On-farm Salmonella reduction programmes with statistically justified monitoring, either bacteriologically (6) or serologically (22), of the Salmonella load of the animals supplied for slaughter. 'Statistically justified' implies that statistics are applied to develop a sampling strategy with as many samples as necessary, but only as few as possible. Research is still needed to evaluate the risk factors for the introduction of Salmonella into herds, and to evaluate the feasibility and effectiveness of Salmonella-reducing measures. An evaluation should also be made of the extent to which the recommended pre-harvest Salmonella-reducing measures contribute to a measurable Salmonella reduction in the final product.

- d) On-farm programmes to reduce the introduction of Yersinia enterocolitica (21, 24), Campylobacter jejuni (20) and Listeria monocytogenes (21). However, additional research on the prevalence of these pathogens in swine herds and on the feasibility of control measures is needed.

**Table 1**

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Ranking of frequency in human diseases in the USA</th>
<th>Relative importance of pork as a source of the pathogen</th>
<th>Ranking of the need for monitoring or control in the pork production chain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campylobacter jejuni</td>
<td>1</td>
<td>+</td>
<td>2</td>
</tr>
<tr>
<td>Salmonella spp.</td>
<td>2</td>
<td>++</td>
<td>1</td>
</tr>
<tr>
<td>Shigella</td>
<td>3</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Escherichia coli 0157:H7</td>
<td>4</td>
<td>–</td>
<td>4 (II)</td>
</tr>
<tr>
<td>Toxoplasma gondii</td>
<td>5</td>
<td>+++</td>
<td>3</td>
</tr>
<tr>
<td>Yersinia enterocolitica</td>
<td>6</td>
<td>+++</td>
<td>6</td>
</tr>
<tr>
<td>Listeria monocytogenes</td>
<td>7</td>
<td>+</td>
<td>5</td>
</tr>
<tr>
<td>Cryptosporidium parvum</td>
<td>8</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Vibrio</td>
<td>9</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Trichinella spiralis</td>
<td>10</td>
<td>+++</td>
<td>6 (II)</td>
</tr>
</tbody>
</table>

= pork is a known source of the pathogen, but other sources are considered more important
++ pork is not the main source of the pathogen, but considered an important source
+++ pork is considered the main source of the pathogen, but other sources are important
++++ pork is unquestionably the main source of the pathogen among meats (excluding game)

a) as pigs are potential hosts for shiga-toxin-positive E. coli, monitoring is advisable
b) real and potential non-tariff trade barriers are more important than food safety concerns

(pathogen)

+++ pork is unquestionably the main source of the pathogen among meats (excluding game)
++ pork is not the main source of the pathogen, but considered an important source
+ pork has not yet been shown to be a source of the pathogen

Due to pathogens, but pre-harvest risk-reduction programmes can either prevent the contamination of the carcass (Trichinella and Toxoplasma) or contribute significantly to minimising the pathogen-associated risks (Salmonella, Campylobacter, Yersinia, Listeria).
High Focus on food production chain

Focus on herd

Standardisation and certification of herd health, food safety and food quality

Focus on single animals

Eradicating pathogens, increasing herd health and production

Controlling epidemics, treating diseases

Low

1920 1950 1970 2000
Year

Fig. 1
The changing role of the veterinarian in food animal practice

To derive the greatest benefit from this development, epidemiological methods for data collection, processing and analysing must be introduced into the daily work of the swine practitioner. The implementation of an information feedback system, as demonstrated in the data flow model for the pork production chain in Figure 2, is necessary in order to have at hand a management tool which combines data from the slaughter plant (disease-related lesions, slaughter deficiencies and monitoring results) with on-farm data on animal health and residues (mortality, morbidity, pathogens and drug use) and on the performance of the herds of origin.

Once this information system has been implemented, there should be few difficulties in dealing with any additional food safety/quality data set to address problems such as animal welfare improvement, e.g. the porcine stress syndrome and transport (2, 6, 11, 19) and/or environmental protection measures (for example, data on antimicrobials in animal excrement and the nutritional use of heavy metals [6, 16, 23]).

As the majority of the data to be recorded are ‘veterinary data’, the food animal practitioner using epidemiological methods plays the key role in developing effective quality assurance systems ‘from farm to table’.

The epidemiological tools needed for the quality assurance approach to food safety (GMP, HACCP and certification) throughout the entire food chain are as follows:

- Quantification of health, disease, risk factors and infection in populations and of contamination and predisposing factors in environments
- Record keeping, data collection, data processing and data interpretation
- Sample strategies for monitoring and surveillance programmes (representativeness, clustering, stratification, bias and confounding)
- Evaluation of diagnostic tests (accuracy, precision, sensitivity and specificity)
- Risk assessment, management and communication
- Outbreak investigation (tracing back and forward, epidemiological teams and task forces, national and international reporting systems).

Conclusion

Providing animals for the production of high quality and certified safe food will make the pork producer a competitive, publicly accepted and appreciated component of the food production chain. The food animal practitioner who makes use of the above-mentioned epidemiological knowledge will play an active role in the process of shaping animal production to a transparent and high quality. Not only will he be a valuable adviser to the producers but also he should assist in contributing to the supply of products of higher quality.

Moreover, the implementation of pre-harvest food safety programmes using information systems as described above, will be the major tool to prevent negative repercussions on national pork exports created by food safety problems. Firstly, the probability of foodborne, pork-related risks to public...
health through pork produced from pigs on farms using a pre-harvest food safety approach is lower than that of traditional farming without any awareness of food safety. Secondly, a pork production chain using a science-based and transparent pre-harvest food safety programme is much more likely to succeed in quelling food safety concerns which are used as non-tariff trade barriers than a pork production chain which does not use such a programme. Without consistent data on the entire production process, the producer would not be able to deliver scientific evidence that the production in question follows the standards and guidelines of the Food and Agriculture Organisation/World Health Organisation (FAO/WHO) Codex Alimentarius Commission and the Office International des Epizooties. However, if a producer can prove that the production of the refused pork meets the internationally approved standards, the ‘Agreement on the Application of Sanitary and Phytosanitary Measures’ (27) – appendix to the Marrakesh Agreement which established the World Trade Organisation in April 1994 – will protect the exporting country against the unfair or unjustified use of food safety concerns as non-tariff trade barriers.

Santé publique et viande de porc : hygiène alimentaire avant l’abattage et perspectives à l’abattage

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Résumé
Les conditions d’exploitation de l’industrie agro-alimentaire en général et de la production de viande porcine en particulier sont en pleine évolution. Les problèmes d’innocuité des aliments et l’assurance qualité intéressent de plus en plus les consommateurs, notamment dans les pays industrialisés. L’auteur décrit les effets sur la filière porcine et la profession vétérinaire du concept de « l’étable à la table » ainsi que la mise en œuvre de la méthode dite de l’analyse des risques, points critiques pour leur maîtrise d’un bout à l’autre de la chaîne agro-alimentaire.

Mots-clés

Salud pública y carne de cerdo: protección alimentaria previa al sacrificio y perspectivas en el matadero

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Resumen
Hoy en día están cambiando las condiciones de funcionamiento de la industria agroalimentaria en general y más específicamente las de la elaboración de productos porcinos. La inocuidad y la calidad de los alimentos son motivo de atención creciente por parte de los consumidores, sobre todo en los países industrializados. Este artículo describe el impacto que tienen sobre la industria porcina y la profesión veterinaria el concepto de continuidad «de la granja a la mesa» y la aplicación de programas de análisis de riesgos y control de puntos críticos a lo largo de toda la cadena agroalimentaria.

Palabras clave
References


