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Food safety through the meat supply chain

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1. SUMMARY

Food poisoning in humans can be caused by many different bacterial genera. While the incidence of food poisoning in England, Wales and Scotland from *Salmonella* has reached a plateau, there has been an increase in the incidence from *Campylobacter*. The incidence from *Escherichia coli* O157:H7 rose to 1997 but declined slightly in 1998 (data from the Public Health Laboratory Service and the Scottish Centre for Infection and Environmental Health). This organism has a high virulence in humans and a very low infective dose. Infection can produce a wide range of responses, including death. The low infective dose presents a major threat. The organism is relatively heat-sensitive and the cooking of food products to achieve a centre core temperature of 70 °C for 2 min is sufficient to destroy it. It is relatively acid-tolerant and will survive for several weeks at pH 4·2. Several foodstuffs, as well as water, have been implicated in world-wide outbreaks. The *E. coli* O157:H7 food-borne outbreak in Lanarkshire in 1996 led to 21 fatalities. The Pennington Group report, issued in April 1997, reported on the circumstances leading to this outbreak, the implications for food safety and the lessons to be learnt. Four areas covered within the Pennington Group report specific to meat hygiene are reviewed in this paper. On-farm practices must ensure the presentation of clean animals for slaughter. There is a requirement for the development and introduction of risk assessment techniques based upon Hazard Analysis of Critical Control Points in abattoirs, and the Meat and Livestock Commission (MLC) is producing a manual for use by the abattoir sector. The Pennington report stated that there was a need for research into the potential use of end-process treatments such as steam pasteurization. The MLC is involved in evaluating such a system. Meat production premises and butchers' shops in England are introducing HACCP through an MLC scheme funded by the Department of Health. At the point of consumption, food safety is improved by the provision of practical guidelines regarding the handling of meat and meat products. These are distributed at retail outlets and communicated to secondary schools via MLC's educational publications.

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2. THE CHALLENGE TO FOOD SAFETY

Food poisoning in humans can be caused by many different bacterial genera including *Campylobacter*, *Yersinia*, *Salmonella*, *Shigella*, *Listeria*, *Escherichia* and the spore-formers, *Clostridium* and *Bacillus*. While the incidence of food poisoning in England, Wales and Scotland from *Salmonella* has reached a plateau, there has been an increase in the incidence from *Campylobacter*. The incidence from *Escherichia coli* O157:H7 increased up to 1997 but declined slightly in 1998 (data from the Public Health Laboratory Service and the Scottish Centre for Infection and Environmental Health).

Escherichia coli O157:H7 (Fig. 1) is a cause of concern to both the public and the meat industry. It has a high virulence in humans and a low infective dose, with literature suggesting that this may be as low as 10–100 organisms. Infection can produce varying responses. These range from mild symptoms through to severe complications and, in extreme cases, death. Typical clinical symptoms of severe cases in humans include haemorrhagic colitis, haemolytic uraemic syndrome (and possible kidney failure) and thrombocytopaenic purpura.

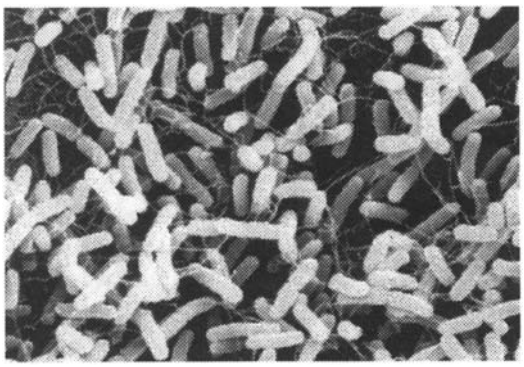

Fig. 1 Scanning electron micrograph of *Escherichia coli* O157:H7. (Picture courtesy of Prof. Pennington, University of Aberdeen)

The low infective dose presents a major threat. Fortunately, however, the organism is relatively heat-sensitive, and cooking of food products, such as burgers, to achieve a core temperature of 70 °C for 2 min is sufficient to destroy it. It is relatively acid-tolerant and will survive for several weeks at pH 4·2. Therefore, the main means of combating this organism are good food hygiene and thermal treatment.

Several foodstuffs have been implicated in the transfer of the organism to humans. One of the first recorded incidences of *E. coli* O157:H7 food poisoning in Great Britain was attributed to potatoes which were undercooked and had previously been stored in peat. Several other foodstuffs have been implicated in world-wide outbreaks. These include undercooked meat and meat products, cross-contaminated meat and meat products, cross-contaminated milk and milk-derived products, unpasteurized apple juice and specific vegetables such as radishes. Water has also been implicated as a source of infection. The incidence of *E. coli* O157:H7 food-borne infection has grown over the last five years, with some 1500 cases being recorded in GB in 1997 (data from the Public Health Laboratory Service and the Scottish Centre for Infection and Environmental Health).

An outbreak of food-borne *E. coli* O157:H7 in Lanarkshire in 1996 led to 21 fatalities. This increased both consumer and industry awareness of the organism and, as a result, the Government commissioned a working group under the Chairmanship of Professor Hugh Pennington. The Pennington Group report (The Pennington Group 1997) reported on the circumstances leading to the Lanarkshire outbreak, the implications for food safety and the lessons to be learnt, and considered action necessary, across the food chain, to provide consumer protection. The Meat and Livestock Commission (MLC) carried out a survey of butchers' shops in Scotland and commented on the interim report of the Pennington Group in 1997. The MLC input to the Group included advice on the physical separation of raw and cooked meats, the licensing of butchers' premises and the likely costs of compliance with the interim recommendations. The MLC report is summarized in an Appendix to the Pennington Group Report. An important point made was that to achieve fully effective consumer protection, the prevalence of the micro-organism across the whole food chain must be reduced.

This Pennington Group report gave clear guidelines for the required response of the meat industry in the light of the increasing incidence of this organism. Following the Pennington Group report, a Joint Industry and Government Working Party was brought together to consider a forward programme for the red meat industry. This Working Party forward programme was published in September 1997 (Government/Industry Working Group on Meat Hygiene 1997).

Four areas covered within the Pennington Group report specific to meat hygiene are reviewed in this paper. They cover practices designed to provide consumer protection, and consider activities on-farm, in the abattoir, in meat production premises and butchers' shops, and at the point of consumption.

3. THE RESPONSE OF THE MEAT INDUSTRY

3.1. On-farm practices

It has been demonstrated (Hadley *et al.* 1997) that the total viable bacterial count on the carcase decreases as the cleanliness of the carcase increases (Fig. 2). It is therefore important that, at the start of the meat supply chain, animals are presented in a clean condition for slaughter. The Meat Hygiene Service (MHS) has produced guideline documents covering contamination on livestock, practices which give rise to contamination and action that can be taken to reduce this contamination. The MHS has also published a clean livestock policy which was widely disseminated to the farming and slaughtering industry through a co-ordinated programme involving industry and Government. This policy is now strictly enforced, resulting in just 0·5% of cattle and 0·6% of sheep being rejected in 1998 for failure to meet the appropriate criteria.

3.2. Abattoirs

3.2.1. Hazard analysis of critical control points. Another element of the defence against *E. coli* O157:H7 for the red meat industry is in the development and introduction of risk assessment techniques based upon Hazard Analysis of Critical Control Points (HACCP) in abattoirs. HACCP is a

Fig. 2 Dirty livestock

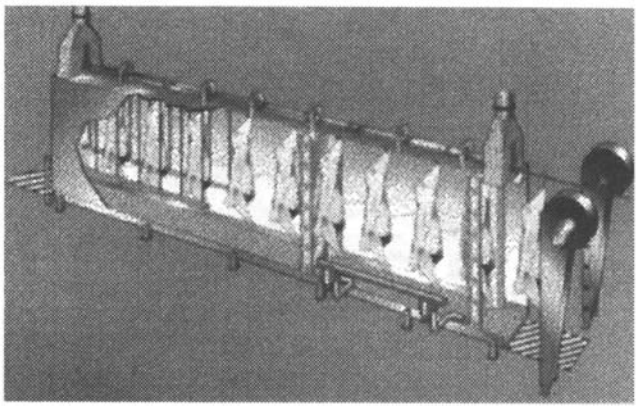

Fig. 3 Artist's impression of the Frigoscandia steam pasteurization unit (SPS®SC Steam Pasteurization System)

system, introduced originally in the 1960s by NASA, to ensure that food taken by astronauts to the moon was safe. It has now become enshrined in world-wide guidelines. It is a risk assessment-based technique with seven key principles:

- Conduct a hazard analysis
- Determine critical control points (CCPs)
- Establish critical limits
- Establish a system to monitor control of the CCP
- Establish corrective action to be undertaken when monitoring indicates that a particular CCP is not under control
- Establish procedures for verification to confirm that the HACCP system is working effectively
- Establish documentation concerning all procedures and records appropriate to these principles and application.

HACCP is commonly being used in the food sector world-wide. This is an area where further development is required for the abattoir sector, and the industry is currently examining means of taking this forward. The Meat and Livestock Commission is producing a generic HACCP manual designed for use by the Great Britain abattoir sector, which will be published in 1999.

3.2.2. Steam surface pasteurization. The Pennington report also recommended research into the potential use of end-process treatments such as steam pasteurization. Such a treatment could act as an important critical control point within an HACCP system for abattoirs.

The MLC is part of a consortium, part funded under the MAFF LINK scheme, which is evaluating the use of steam pasteurization of beef carcases, from British sourced cattle, in British abattoir facilities. This technique is now widely used in the United States to improve food safety, but a number of differences between the industries in the US and Britain result in a need to carry out a controlled evaluation of the benefits of the system here. The consortium, comprising MLC, Frigoscandia Equipment (FMC FoodTech), Campden and Chorleywood Food Research Association, Dawkins International, Dawn Meats, The University of Nottingham and Marks and Spencer, came together to carry out this work.

The steam pasteurization system (Fig. 3) is basically a three-step process aimed at the reduction of micro-organisms on the surface of a carcase side. Each side passes between a pair of air blowers to remove surface water before entering a stainless steel chamber. This chamber is filled with condensing steam which heats the carcase surface rapidly. It is the combination of the temperature achieved at the surface of the carcase and the time of exposure which will determine the degree of reduction in micro-organism numbers. This is followed by a spray with chilled water to cool the surface in order to avoid over heating and hence, thermal damage and excessive discoloration.

American field trials have shown a 1–2 log reduction in coliforms, and that the system is effective against *E. coli*, *Salmonella typhimurium* and *Listeria monocytogenes.* The reduction observed in trials depends on the initial population of the organisms, and this is one reason why it is considered necessary to examine the system under British conditions. The equipment used in the US is too large for most British abattoirs and therefore, Frigoscandia Equipment have developed smaller equipment that will fit into British plants. This new design needs to be evaluated. In addition, it is important to examine the re-growth of organisms following treatment, as the British industry makes extensive use of ageing or maturation to enhance the

eating quality of beef. Reduced competitive flora may make re-growth of pathogens an issue during ageing. It is also necessary to optimize the process parameters (time and temperature) to ensure efficacy of bacterial kill with minimal surface discoloration.

The work programme has four main phases:

- Design, construction and commissioning of equipment
- Determination of optimum treatment parameters ('optimization study')
- Determination of renewed growth of contaminants relative to unpasteurized sides to ensure that, having removed competitive flora, the risk from pathogens is not increased ('recontamination study')
- Large-scale evaluation of the technology in a commercial supply chain.

It is hoped that this project will result in a means of providing safer beef, with improved storage flexibility (through reduced spoilage) and competitive advantage in the beef export market.

3.3. Meat production premises and butchers' shops

The Pennington Group report discusses meat production premises and butchers' shops and, in particular, recommends the adoption of HACCP by all food businesses to ensure food safety. The report also recommends that the Government should seek to enshrine HACCP in legislation. The MLC, together with the Department of Health, are implementing a project called 'Accelerated HACCP in Butchers' Shops' in England. Separate measures are being undertaken in Wales and Scotland. The English initiative is concerned with the development and introduction of HACCP on a voluntary basis in advance of legislation. The project initiative has several stages initially involving the development of a generic HACCP scheme and the development of a meat hygiene and HACCP course (Fig. 4).

The project then extends to the selection of training providers and consultants, and their use of the HACCP manual and training course. The selected trainers train butchers in the use of HACCP, with separate selected consultants providing assistance in the implementation of the technique in the butchers' premises. By mid-October 1999, over 6500 butchers had been trained and over 3000 had been signed off by consultants, to the effect that they are now practising HACCP on their premises.

The development of the HACCP manual and course has been carried out in conjunction with the Chartered Institute of Environmental Health (CIEH), Local Authorities Co-ordinating Body Food and Trading (LACOTS), the Royal Institute of Public Health and Hygiene (RIPHH) and the Meat Training Council (MTC).

Fig. 4 Manuals for programme of introduction of HACCP into butchers' shops

3.4. Point of consumption

It is important to ensure that hygiene in the food chain is carried through to in-home practice. From time to time, the MLC issues guidelines to the consumer covering practical messages regarding meat and meat products for distribution at retail outlets. The type of message conveyed in these materials include:

- When taking meat home, refrigerate or freeze as soon as possible
- Clean and disinfect surfaces before food preparation, and between preparing cooked and raw food
- Wash your hands before and after handling food
- Keep raw and cooked food separate in the kitchen
- Store raw foods lower in the refrigerator than cooked foods
- Check storage temperatures. These should be 0–4 °C for a refrigerator and −18 °C for a freezer
- Follow cooking instructions
- Cook sausages and burgers right through until the juices run clear, and never eat them rare
- Only re-heat cooked meat dishes once and make sure they are piping or boiling hot
- Always thaw meat thoroughly and ensure liquid from frozen meat does not drip onto other food.

These practical guidelines have been communicated to secondary schools via the MLC's educational publications.

4. CONCLUSION

Ensuring the safety of meat consumed involves everyone in the food supply chain taking responsibility for the meat while it is in their care. This includes the presentation of livestock in a clean condition fit for slaughter, the use of HACCP in the abattoir, research into end-process technol-

ogies and the proper handling of meat by retailers and in the home. The meat industry takes its responsibility to produce safe wholesome food very seriously indeed.

5. REFERENCES

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