Routes of salmonellae contamination in pig lairages and the development and evaluation of simple cleaning methods

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Abstract

The aim of this project was to identify, and validate, the best "lairage-to-stunning" practices to reduce cross-contamination, and to assess the general status of the lairage hygiene and lairage cleaning effectiveness in UK abattoirs.

A survey of a large number of UK abattoirs was conducted via a questionnaire designed to obtain information on lairage construction and operation. A representative group of abattoirs was selected on the basis of the responses to the questionnaire and the lairage at these plants investigated through enumeration of *Escherichia coli* remaining after routine cleansing operations. The results of these visits showed that the *E. coli* indicator was not completely removed from abattoir lairages by standard cleaning practices. Follow up work indicated that routine cleansing measures in commercial abattoirs are insufficient to remove Salmonella contamination from the lairage environment, and the incidence of *Salmonella* spp. on pig carcasses is quite high.

Based on the results of the abattoir survey, an experimental study was conducted to evaluate the efficacy of different cleaning regimes. Concrete tiles were artificially contaminated with field strains of *E. coli* and *Salmonella Kedougou*, with and without the presence of bovine faecal matter. This simulated visually clean and visually dirty surfaces respectively. They were then cleaned using a specially designed mechanical rig. Cleaning was carried out using: 1) water at mains pressure, 2) water under pressure, 3) water under pressure with a proprietary sanitising agent, 4) steam under pressure and combinations of 5) mains water followed by steam under pressure, or 6) water under pressure followed by steam under pressure.

Introduction

Recent studies, funded by the UK Food Standards Agency and conducted at the University of Bristol, as well as recent studies abroad, have indicated that significant environment-to-animal microbial cross-contamination takes place in the lairage-to-stunning areas in abattoirs. The results also indicate that routine cleaning regimes in commercial abattoirs are very variable and often appear inadequate to reduce/prevent that cross-contamination.

Relatively high prevalence of foodborne pathogens (particularly *E. coli* O157) on animal coats post-stunning has been demonstrated, and a high risk of coat-to-carcass transfer of these pathogens during dressing exists. However, the work had concentrated on sheep and cattle slaughtering and less data appeared to be available on pork slaughtering. Therefore the aim of this project was to identify, and validate, the best "lairage-to-stunning" practices to reduce cross-contamination of animal coats during that phase and to assess the general status of the lairage hygiene and lairage cleaning effectiveness in UK abattoirs and at the same time extend the study to cover pork slaughtering operations.

Literature review

A comprehensive review of relevant information from previous studies, published papers and other sources was conducted on various pre-lairage factors potentially affecting contamination of lairages and also data on contamination in the lairage itself.

The lairage is the delivery and final point where the animal is penned before slaughter. Following arrival at the abattoir, animals are placed in the lairage for a holding period. This holding period serves a number of purposes; it allows animals to recover (to a certain extent) from the stresses associated with marketing and transport; it provides the opportunity for animals to clean up and/or dry out if required; and it is reported that 'resting' pigs in lairage for at least 12 hours leads to better bleeding, a reduction of endogenous contamination, a restoration of glycogen content and a reduction of intestinal bacterial load with the intake of plenty of water (Yadava, 2002). Rostagno *et al.* (2003) demonstrated that pig lairage pens became highly contaminated with salmonella, and the water source was also found to be contaminated. This was identified as the critical source of infection because pigs that were negative following transport subsequently became positive after penning.

The survey data provided the UK-wide, basic, information needed for rational design and optimising, of the experimental and validation work in subsequent objectives.

Postal survey of UK abattoirs

A survey of a large number of UK abattoirs was conducted via a questionnaire designed to obtain information on:

1. Throughput and species slaughtered.
2. Construction materials used.
3. Use and type of bedding.
4. Details of cleaning/sanitation regimes.

Twenty three of the responding abattoirs processed pigs and a detailed analysis of the data obtained can be found in Small *et al.* (2006).

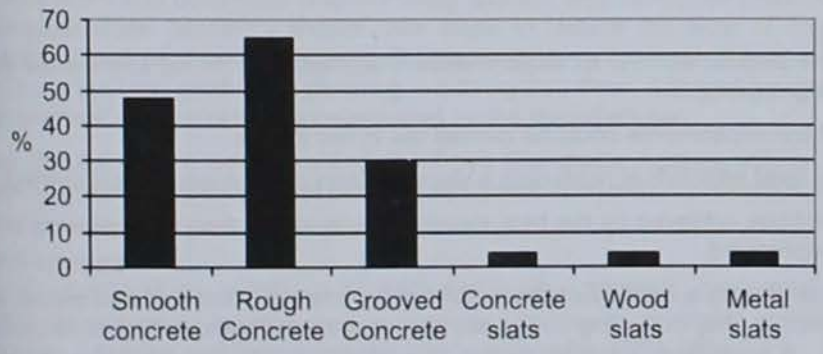

Figure 4. Flooring types in pig lairages.

The materials used and the type of construction varied between abattoirs however the floor of lairages was predominantly concrete, but it could be smooth, rough or grooved (Figure 4). Cleansing practices in the premises surveyed were very variable. Small premises were more likely to thoroughly wash and disinfect the lairage after each working day. This may be a function of the fact that these premises operate on one day each week, and have more time available to thoroughly clean the premises. On the whole, holding pens were washed out on a daily basis, and the race, stun box and roll-out ramp at each break. Chemical agents tended to be used daily in the stun box and roll-out areas, which are more likely to be considered as part of the slaughter hall, and weekly in the race and holding pens, if they were used at all.

Site visits

A representative group of abattoirs were selected on the basis of the responses to the questionnaire and the lairage at these plants investigated through enumeration of *E. coli* remaining after routine cleansing operations. In pig abattoirs the floors of the holding pens tended to be more highly contaminated than the walls (Table 5). A detailed analysis of the data obtained can be found in Small *et al.* (2007a).

Table 5. Mean *E. coli* counts (log_{10} cfu cm^{-2}) in holding pens.

Abattoir	Site Holding Floor Pen	Holding Wall Pen	Holding Edge Pen	Holding Corner Pen
A	0.4^{b} (1.7)	$-1.7^{d,e}$ (0.8)	1.0^{f} (0.9)	$0.3^{g,h}$ (2.5)
B	0.8^{b} (1.9)	$-1.3^{c,d,e}$ (1.1)	1.2^{f} (2.0)	$1.3^{g,h}$ (1.9)

Standard deviations shown in parenthesis, Values sharing similar superscripts are not statistically different.

The results of these visits showed that the *E. coli* indicator was not completely removed from abattoir lairages by standard cleaning practices. Thus lairages may allow a risk of transfer of contamination from one processing day to the next. Potentially, bacteria such as salmonella may be transferred to the outer surfaces of animals held in the lairage facilities, and the skin or hide is a significant source of microbial contamination on the red meat carcasses subsequently produced. To determine if this was the case, a second round of plant visits collected samples (n=556) from lairages and red meat carcasses (n=1050) in commercial abattoirs in the South-West of England. The samples were tested for the presence of *Salmonella* spp. 6.5% of lairage samples were positive, containing estimated numbers of up to 104 Salmonellae per sample. Of carcass samples, *Salmonella* spp. was found on 31% of pig carcasses. These results indicate that routine cleansing measures in commercial abattoirs are insufficient to remove Salmonella contamination from the lairage environment, and the incidence of *Salmonella* spp. on red meat carcasses is quite high, although the implications of residual lairage contamination on carcass meat microbiology are not clear from this study.

Experimental cleaning

Based on the results of the abattoir survey, an experimental study was conducted to evaluate the efficacy of different cleaning regimes.

Initially it was thought that the experiments could be carried out in two stages.

1. Systems that were most effective at producing a visually clean surface would be identified.
2. The microbial reductions achieved by the best visual systems would then be evaluated and their performance optimised.

A search was carried out to identify a method of physically contaminating a surface, that would: a) be repeatable; b) be similar to that occurring in an abattoir; and c) allow the effect of different systems to be quantified. A number of possible visible contaminants, i.e. shaving foam, butter, honey, powder paint, grease, etc, were identified. However, in initial trials none were found to even approach the performance required. With some, it was difficult to produce a repeatable application on a concrete surface. With others, all the cleaning methods of interest either removed all traces of the contaminant very quickly or failed to remove them at all. Initial trials with typical (faecal) lairage contamination showed that in practice most rudimentary cleaning systems could produce a visually clean surface relatively quickly.

A decision was therefore made to concentrate on the microbial reductions that could be achieved. Concrete tiles were artificially contaminated with field strains of *E. coli* and *S. Kedougou*, with and without the presence of bovine faecal matter. This simulated visually clean (but contaminated) and visually dirty surfaces respectively. They were then cleaned using a mechanical rig that was designed to produce a repeatable treatment. Cleaning was carried out using: 1) water at mains pressure, 2) water under pressure, 3) water under pressure with a proprietary sanitising agent, 4)

steam under pressure, and combinations of 5) mains water followed by steam under pressure or 6) water under pressure followed by steam under pressure. Thirty replicates of each of visually clean and visually dirty concrete surfaces were cleaned using each method.

The results showed that where there was no faecal matter, the use of a proprietary sanitiser at the maximum recommended concentration, or the application of steam under pressure gave greater reductions in microbial contamination than the use of mains or a pressure wash. Where the surface was visually contaminated with the faecal material, the use of a pressure wash followed by immediate steam application gave reductions in microbial contamination comparable with the use of a proprietary sanitiser at maximum recommended concentration. The use of steam alone on a visually dirty surface was not an effective means of reducing microbial contamination. A small pilot trial under commercial conditions ranked the efficacy of cleaning treatments as follows:

1. Pressure washing followed immediately by steam application.
2. Use of a sanitising agent at the greatest concentration recommended by the manufacturer, and then by pressure washing alone.
3. Pressure washing followed by a delayed steam application appeared to give a poor final result on the surface.

A full analysis of the data obtained can be found in Small *et al.* (2007b). It was concluded that further work is required to explore the interactions between the angle of application, pressure of jet, and temperature of cleaning fluid, all of which may impact upon the effectiveness of the cleaning procedure. Similarly, alternative proprietary chemical cleaning agents may have effects dissimilar from the Janitol sanitiser used in this study. There may be a significant impact of climatic or environmental conditions on the change in microbial contamination of a surface during the drying phase.

Conclusions

Overall the study has shown that at present microbial contamination, including Salmonella, often remains in UK lairage holding pens after routine cleaning operations. It would appear that there are significant differences in the effectiveness of lairage cleaning programmes at commercial abattoirs, and that the stuning-roll-out areas are often cleaned to a better standard than the holding areas. As a result, there is a possible the risk of foodborne pathogens persisting in the environment and potentially contaminating animals and carcasses processed on subsequent days. Slaughterhouse operators should take steps to reduce the level of contamination both in their premises and on their carcasses. Pressure washing followed immediately by steam application appears the best method of cleaning a holding pen floor, followed by use of a sanitising agent at the greatest concentration recommended by the manufacturer.

The results of this work provided the Food Standards Agency with a scientific base to derive related guidelines for the meat industry, which will ultimately contribute to improved meat safety.

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