

# Meat Technology Update

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## Pathogen reduction interventions for carcasses

In late 2002 FSIS made recommendations in their Guidance Document 'Guidance for minimising the risk of *Escherichia coli* O157:H7 and Salmonella in beef slaughter operations' about the use of decontamination techniques as slaughter floor interventions and about in-plant validation of interventions as critical control points (CCPs). As a consequence of the recommendations, some US purchasers of Australian bulk-packed beef are seeking confirmation that processors in Australia have at least one of several interventions listed by FSIS in place on the slaughter floor. Further, they are seeking confirmation that at least one of the interventions is designated as a CCP and that its effectiveness has been validated.

Many decontamination technologies have been subjected to scientific trials over the years. This Update discusses some of those which are used commercially here and in the US, including those recommended by FSIS. It does so by considering their effectiveness, reliability and likely cost to install and operate. Some other technologies that are showing promise in recent scientific investigations are also discussed.

### Trimming of carcasses

Since 1994, AQIS has prescribed zero tolerance for the carcass contaminants ingesta, faeces, milk and urine. In July 1996, USDA published a Final Rule that mandated the introduction of HACCP plans and sanitation-standard operating procedures (SSOPs) in all establishments that supply to the US market. Zero tolerance for visible contamination of the carcass by ingesta, milk, and faeces was an important component of the Final Rule. In most cases, trimming of the affected product is an acceptable corrective action.



**Figure 1. Hot water treatment of beef sides in an Australian abattoir.**

Whilst an establishment's system of removal of macro-contamination by faeces, ingesta, urine and milk (i.e. any contamination including smears or specks that are visible to the observer) may be very reliable, the efficacy of general trimming in reducing the microbial contamination on carcasses is questionable. Laboratory studies have

often reported large reductions as a result of trimming but these have been obtained under controlled conditions using visible contamination and do not provide a realistic evaluation of the effectiveness of routine trimming in a commercial environment. Few studies have been conducted using naturally contaminated carcasses. While some American studies have reported good reductions from trimming, others have not.

In a Canadian study, trimming appeared to have little effect or may have even resulted in slight increases in bacterial numbers at the sites observed; and, in a study at three Australian abattoirs, the effect of trimming and washing resulted in an increase in numbers of *E. coli* on beef carcasses and a corresponding increase in prevalence. Based on these variable findings, it would be inappropriate to nominate trimming as a CCP.

## Steam vacuum systems

Steam vacuum systems are used in Australia for removal of wool fibres and wool dust from sheep carcasses but they are used infrequently as interventions for beef sides. AQIS Meat Notice 98/1 states that the unit must be used for localised 'spot' treatment only and should be applied to a particular area of the carcass surface for a five-second contact time.

Steam vacuuming is widely used in the US. Several of the published studies of steam vacuuming by US researchers in the late 1990s were pilot studies; however, they were not extended to investigations of sides on a slaughter floor; they have limited relevance when considering a whole side in the normal commercial situation where faecal contamination is infrequent; and, when used for spot treatment as directed by AQIS, there would be opportunity to treat only very limited areas of a side.

In 1997, a steam vacuuming study in two Australian abattoirs showed reductions of the order of 1 log<sub>10</sub> units in coliforms on treated areas of beef sides.

In a US study involving two brands of steam vacuuming units and five processing plants, steam vacuuming reduced total plate count (TPC) and total coliform counts (TCC) on carcass surfaces soiled with visible contamination by around 2 log<sub>10</sub> units (100-fold); however, for surfaces that had no visible faecal contamination, the reductions in TCC were only around 0.3 log<sub>10</sub> units (two-fold).

In summary, for plants where good manufacturing practice is followed and visible faecal and other material on dressed sides is infrequent, steam vacuuming would be minimally effective as a microbiological intervention.

## Organic acids

In Australia, the use of lactic or acetic acids as interventions for beef sides is limited. There are several reasons for this. Within the European Union, meat hygiene regulations do not allow their use. Processors who export to the EU cannot apply anything to carcasses other than potable water during a washing process.

Secondly, while data collected from commercial efficacy trials in Australia and elsewhere have shown an average 1.5 log<sub>10</sub> units reduction in total aerobic bacteria, they have not always given encouraging results for *E. coli* and other pathogens. In a 1995 Australian trial using a commercial spray cabinet, reductions using lactic acid were dependent on ambient temperature conditions, the solution temperature, and location on the beef side. For spray application and a temperature at the carcass surface of 15°C, reductions on neck tissue after treatment were just 0.5 log<sub>10</sub> units. Too little is yet known about the process controls necessary to give good reliable results with organic acids.

Another reason for their limited use, is the potential to corrode equipment and create an uncomfortable work environment.

There is documented evidence of the acid resistance of *E. coli* O157:H7 and an indication that survival may increase when acetic acid rather than lactic acid is used for carcass decontamination. The efficacy of organic acids as carcass interventions might therefore be reduced. The US author of one paper published in 2002 commented that the use of organic acids must be considered with some degree of caution, in light of recent research indicating that acid adaptation of *E. coli* O157:H7 and other pathogens may occur in dilute decontamination fluids in meat-packing plants.

## Water washing systems

Data cited in the FSIS Guidance Document from two US studies of model systems in the laboratory indicate that water washing could achieve reductions in *E. coli* O157:H7 (applied in faeces) up to 3.5 log<sub>10</sub> units. However, in one of the studies from which the data were obtained, washing with water alone was found to be the least-effective treatment of several that were used. Results obtained here in an Australian abattoir in 1995 from a wash cabinet in which beef sides were washed with warm (40°C) water indicated reductions in numbers of faecal coliforms of as little as 0.1 log<sub>10</sub> units on surface tissue from the neck region of sides (Figure 1).

Hot water washes are used commercially in Australia and North America for decontamination of beef sides. A 1999 Canadian study indicated that commercial hot water pasteurisation of beef sides reduced numbers of coliforms and *E. coli* by around 2 log<sub>10</sub> units. Results from the Australian system indicate reductions of this order, and higher. Generally, recirculation of water is necessary otherwise water consumption is prohibitive. Systems need to be carefully designed with adequate controls, particularly where they are to be identified as CCPs, otherwise downtime will result in the frequent need for appropriate corrective action.

## Steam pasteurisation

The FSIS Guidance Document refers to studies of steam pasteurisation that have been published, indicating reductions in numbers of *E. coli* O157:H7 of 3 to 4 log<sub>10</sub> units. While these appear to be model studies in general rather than commercial ones, a Canadian study indicated that the Frigoscandia pressurised steam

process reduced the numbers of coliforms and *E. coli* on beef sides in a commercial beef-packing plant by at least 2 log<sub>10</sub> units.

Steam pasteurisation has been used in packing plants in the US with apparent variable results. There have been reports of reductions less than 1 log<sub>10</sub>. For these reasons, while plants may consider it as a decontamination step, they should disincline to designate it a CCP. As indicated later in this document, steam pasteurisation systems are likely to be quite expensive to install in Australia.

## Other treatments

### *Sequential decontamination*

The benefit of applying multiple, sequential decontamination treatments has been demonstrated in commercial beef slaughter plants in the US. One trial conducted in several plants evaluated combinations of steam vacuuming, pre-evisceration carcass washing, pre-evisceration organic acid rinsing, hot water, post-evisceration final wash and post-evisceration organic acid washing. The trial indicated that numbers of *E. coli* and other bacteria declined through the various stages of the slaughter process as the various interventions were progressively applied.

### *Chlorine*

Chlorine at 20-50 ppm was included in a list of approved antimicrobial treatments by FSIS in 1995; however, the effects of carcass treatment with solutions of up to 250 ppm chlorine have been variable, with some insignificant reductions being reported. Interestingly, chlorine was not among the alternatives suggested by FSIS in 2002. Also, the use of high chlorine levels is not acceptable to EU markets.

### *Chilling of sides*

Chilling of sides is discussed in the Guidance Document, though not as an intervention. There is some evidence that chilling *per se* can be regarded as an intervention. In their discussion of results of steam pasteurisation in a commercial packing plant in Canada, scientists there observed that counts of coliforms and *E. coli* declined to a greater extent when numbers were assessed after chilling, than immediately after the steam pasteurisation. They commented that the microbiological effects of the pasteurising treatment appeared similar to those of the cooling process on non-pasteurised carcasses, as both reduced the log numbers of coliforms and *E. coli* by more than 2 log<sub>10</sub> units.

Similar observations have been made in Australia where dry air chilling is employed. Chilling appeared to reduce counts of coliform bacteria by up to 1 log<sub>10</sub> after warm water washing, hot water decontamination, and organic acid treatments. It is widely accepted that effective chilling involves several factors, particularly air temperature, relative humidity, air speed and carcass spacing; however, the values and tolerances for these parameters have yet to be adequately established for chilling to be nominated as an intervention step and a CCP.

### *Activated lactoferrin*

Activated lactoferrin, a protein that can be found naturally in various animal fluids, has recently been approved by USDA for use on fresh beef. Its antimicrobial properties have been demonstrated against several bacterial pathogens including *E. coli* O157:H7 and *Salmonella*.

### *Pre-slaughter treatments*

Sodium chlorate has recently shown promise in the US as a supplement in feed rations and in drinking water. Initial trials have demonstrated a 2 log<sub>10</sub> units or more reduction in *E. coli* O157:H7 in the rumen and faeces of cattle. Results from more extensive trials are necessary and approval for its use is required; however, it appears not to have any negative effect on meat quality. Approval by the Food and Drug Administration is pending, so the promising initial results suggest that supplementation may be a practical way to reduce numbers of the organism and reduce the risk of contamination of carcasses.

Some animals are visibly dirtier at slaughter than others. Those transported over long distances are likely to be dirtier than animals transported over short distances; and, lot-fed cattle – particularly British breeds – frequently are visibly dirtier than others; however, various investigations in Australia and overseas have produced little, if any, evidence of a direct relationship between visible dirt on hides or fleeces and bacterial contamination on carcasses.

There have, however, been promising investigations, of some chemical processes to clean animals just before slaughter or the bodies after slaughter but before hide removal.

An example is chemical dehairing which was evaluated at the now defunct Future Beef packing plant in Kansas; however, their effectiveness in routine use has yet to be proven.

## How effective need interventions be?

The reason for installing intervention systems is to reduce the likelihood of pathogens being present on the carcasses and meat. *Salmonella* and *E. coli* O157:H7 are the main targets of carcass pathogen-reduction programs. From their own testing programs, abattoirs should know the prevalence for each in their establishments. In a 1998 national survey, *Salmonella* was detected on 0.2% of carcasses and *E. coli* O157:H7 on 0.1%. It is very likely that the actual numbers of the pathogens on the positive carcasses are low – perhaps just a few cells per sample. Therefore it follows that a decontamination treatment that achieves a reduction of 1 log<sub>10</sub> unit would probably reduce the number of carcasses testing positive for the pathogens by a similar amount. In Australia, systems that provide reductions of 1-2 log<sub>10</sub> units would therefore be considered effective.

Few data are available from in-plant trials of interventions in Australia. Those that are available have been mentioned previously. In 1997, the Meat Research Corporation commissioned Texas A & M University (TAMU) to evaluate various combinations of interventions for beef carcasses in terms of their effectiveness and cost. TAMU

scientists deliberately contaminated 400 cm<sup>2</sup> areas of test sides with faeces containing high numbers of the pathogens *Salmonella* and *E. coli* O157:H7. Various selected intervention treatments were directed at the visibly contaminated areas. Under those conditions, several interventions including trimming and steam vacuuming reduced numbers by up to 4 log<sub>10</sub> units and some combinations of treatments achieved up to 5 log<sub>10</sub> units.

## What are their costs?

The research team also surveyed several abattoirs in Australia and derived estimates of fixed and variable costs for installing and running the selected treatments. The estimates below (given here in 2003 dollars) are for a plant killing 70 head per hour. They are for treatments that the team believed should achieve reductions in numbers of at least 2 log<sub>10</sub> units. For hot water preceded by a warm water wash, the fixed cost would be of the order of \$400,000. This, together with the variable costs (water, steam, labour etc.) gives a total cost of \$0.64 per carcass. For steam pasteurisation, the fixed cost for an installation was estimated to be \$630,000 and the total cost \$0.77 per carcass. Many packing plants in North America employ multiple interventions – they might be a pre-visceration lactic acid wash, steam vacuuming and trimming, followed by either hot water decontamination or steam pasteurisation. The matrix prepared by Texas A & M included several combinations. The combination of water wash, lactic acid spray and hot water was costed at \$1.11 per carcass; that of water, steam pasteurisation and lactic acid at \$1.24; and steam vacuuming, lactic acid and hot water at \$1.85 per carcass.

## Further reading

USDA Food Safety and Inspection Service  
[www.fsis.usda.gov](http://www.fsis.usda.gov)

FSIS Guidance Document:  
<http://www.fsis.usda.gov/oppde/rdad/frpubs/00-002N/BeefSlaughterGuide.pdf>

Huffman, R. D. (2002) Current and future technologies for the decontamination of carcasses and fresh meat. *Meat Science*, 62: 285-294.

## Interventions as CCPs

Following the release of the USDA documents in 2002, some US clients have been encouraging Australian processors to designate decontamination interventions targeted at *E. coli* O157:H7 as CCPs; however, you should consider the ramifications carefully before doing so. CCPs have to be validated for effectiveness and reliability, and critical limits for performance have to be nominated. As yet, there is not an agreed in-plant procedure for validation. Also, in the event that the critical limits aren't being met (as would be the case if there was a breakdown of the system for instance), corrective actions have to be implemented. The corrective action might be to stop the slaughter-floor chain until the fault is rectified, or quarantine the untreated carcasses until they are treated and shown to be free of the pathogen.

*The information contained herein is an outline only and should not be relied on in place of professional advice on any specific matter.*

**For more information, contact one of the Meat Industry Services staff listed below.**

### Food Science Australia Meat Industry Services Section

The Meat Industry Services (MIS) Section of Food Science Australia is an initiative supported by Meat and Livestock Australia (MLA) and the Australian Meat Processor Corporation (AMPC) to facilitate market access for, and support world-class practices in, Australia's meat industry.

**Need additional information help, information or advice?** Contact any of the following

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