

Meat technology update

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Sources of contamination on beef carcasses during dressing

- **The biggest source of contamination during dressing is the hide. Good hygiene practices during hide opening can minimise this risk.**
- **Gut content is another source of contamination. Good practices involving rodding, bunging and prevention of rupture minimise this risk.**
- **Personnel and their equipment can also constitute a significant source of contamination.**
- **Strict attention to hand-washing practices and the wearing of gloves will minimise the risk from personnel.**

During carcass dressing, contamination can arise from the workers, the equipment and from the bodies being processed. The animals are the most significant source of contamination of the resulting carcasses. In most cases, the deep tissues of healthy livestock at the time of slaughter are bacteriologically sterile and contamination is introduced onto the meat surfaces during the dressing process.

E. coli O157 or other pathogens in the faeces or on the hide of slaughter animals can be transferred onto the carcass during dressing. Interventions designed to control or reduce bacterial contamination of carcass surfaces, such as steam pasteurisation, or carcass rinsing with organic acids and other substances, are used in many processing plants around the world to assist in minimising the effect of cross-contamination. The interventions can each result in a decrease in microbial numbers on carcasses, but the use of multiple decontamination procedures has an additive effect and increases the possible microbial reductions.

Contamination from the environment can also be significant during primary processing. Studies of pig and poultry processing plants have found that up to 25% of samples taken from surfaces in the slaughterhall contain *Salmonella*. The normal cleaning and disinfection procedures in the abattoirs examined did not eliminate the organism. The hands of the workers on the line also become contaminated through handling contaminated animals. In a study where *Salmonella* were deliberately inoculated onto hands, the organisms were detected on fingertips three hours after inoculation. Washing and drying of hands reduced the number of organisms present, but did not eliminate them.

Contamination arising from the gut

The intestines of animals contain large numbers of microorganisms, with *E. coli* levels usually greater than 10^5 cfu/g, and amongst these microorganisms may be found foodborne pathogens such as *E. coli* O157, *Salmonella* and *Campylobacter*. There is a risk that intestinal contents may contaminate carcasses during evisceration if practices are poor, or if the gut is ruptured. Normal work practices by trained staff, including rodding and bunging, rarely result in such occurrences and the hygiene risk posed by the gut contents is substantially less than that posed by the microbiological load on the skin of the animal.

It has been recommended that animals are fasted prior to slaughter to reduce the gut volume and reduce the risk of spillage of intestinal content during dressing. Animals are fasted before slaughter, but fasting times are variable depending on marketing and transport conditions. Prolonged fasting, or interrupted fasting, may increase the number of pathogenic bacteria carried by animals and deposited into the lairage and slaughterhouse environment. In cattle, a period of feed withdrawal can cause a rise in rumen pH, which may favour the survival of *Salmonella* and promote a slow rise in faecal *E. coli* content over a 24–48 h period.

In general, carcass contamination by pathogens is related to carriage of the organisms in the live animal. For example, reducing the prevalence of *Salmonella* carriage in the intestines of live pigs can substantially reduce the incidence of the organism on pig carcasses.

Contamination arising from the hide

Enormous numbers of organisms are also associated with the hide, hooves and hair of cattle. The surface contamination of hides has been found to range from 3.53 to 12.5 \log_{10} cfu/cm². Contamination tends to be higher in winter than in summer and the brisket is the most heavily contaminated area. These



microbial levels can be greater than that cited for intestinal contents or faeces (e.g. approximately $5 \log_{10}$ cfu/g). This is possibly due to the high proportion of other organic and inorganic material in faeces contributing a dilution effect on the concentration of microorganisms. In addition to microbial counts being greater on hides than in faeces, recent work in Australia has shown that in a number of cases, cattle hides carried a higher prevalence of foodborne pathogens than the faeces. A New Zealand study found that where hides were visibly contaminated with faeces, the *E. coli* count could be around $3.10 \pm 1.02 \log_{10}$ cfu/cm²; and a US study was in broad agreement, finding a range of 2.08 to $7.5 \log_{10}$ cfu/cm² *E. coli* count. Australian researchers found *E. coli* O157 on cattle hides at levels of up to $2.24 \log_{10}$ cfu/cm². *Salmonella* has also been found in hair samples at $6.6 \log_{10}$ cfu per gram. In comparison, on sheep fleece, the mean microbial level has been found to be $5.38 \log_{10}$ cfu/cm², with no real seasonality.

The hide of cattle and the fleece of sheep are a significant source of microbial contamination of the carcass. Good evidence has been found (through comparison of isolates from carcasses originating from separate producer groups), that cross-contamination between hides occurs in the abattoir lairage. Immediately after hide removal, carcass counts are reported to be 6.1–7.9 \log_{10} cfu/100cm² total viable count (TVC), 3–6 \log_{10} cfu/100cm² total coliform count and 2.6–5.3 \log cfu/100cm² *E. coli*. Carcass decontamination and chilling significantly reduces this level.

These reported counts, mostly from the northern hemisphere, are substantially higher than the carcass counts found in Australian processors. The latest Australian baseline found $1.33 \log_{10}$ cfu/cm² on carcasses after chilling, and *E. coli* were detected on only 4.9% of samples.

Visual cleanliness of hides shows no consistent effect on dressed carcass contamination, but is generally considered to result in cleaner carcasses. One study found that increasingly greater dag (dried mud and faeces) adhering to the hair (see figure 1) increased the carcass coliform count. This study found that slowing the slaughter line or shaving dag off cattle hides could reduce carcass contamination.

In general, the wetter the hide of the animal, the greater is the carcass coliform count. A study in which the hair surface of hides was deliberately allowed to contact the carcass surface showed that carcass contamination is significantly lower following contact with clean hides than following contact with faecally soiled hide that had been washed prior to slaughter. In fact, contact with wet pre-slaughter washed hide resulted in a carcass microbial load similar to that resulting from contact with fresh faeces. Microbiologically, total counts on beef carcasses have been found to be an almost constant fraction of those on hides (0.3% was suggested in the 1970s), but this fraction differs between abattoirs, and is worth exploring as a means of monitoring process hygiene. Faecal and hide prevalence of *E. coli* O157 are significantly correlated with carcass prevalence.

Cleaning livestock prior to dressing

As a result of the association between dirty hides and high carcass microbiological counts, some countries have introduced a 'clean livestock' policy, and use a subjective rating system for assessing the cleanliness of cattle presented for slaughter. Although mobs of cattle that are scored 'cleaner' will tend to give lower carcass microbial counts, there does not seem to be a consistent relationship between cleanliness score for an individual animal and its own carcass microbial load. However, the scores within each sale lot tend to be similar, and this makes the system a useful tool.



Figure 1: Excessive dag adhering to the coat will not only make hide opening difficult, but also lead to carcass contamination (Archive photograph from European research team)

Where animals are rejected on account of dirtiness, there are attempts to clean the hides prior to slaughter or prior to hide opening. Such measures have not been shown to provide a significant reduction in carcass microbial count. Clipping long-haired animals prior to slaughter has been advocated to improve the microbial status of the resultant carcass, and is commonly practised with respect to sheep in a number of countries. Its use with cattle is limited as it can cause stress. Pre-slaughter removal of dags is an immensely hazardous task for the operator. Also, if the hide is damaged it will lose value as a saleable by-product. Furthermore, it is possible that clipping cattle immediately prior to slaughter, or prior to hide opening, will increase contamination of the resulting carcass, as numerous small hair clippings can be observed along the cut-lines on carcasses of recently-clipped cattle. Researchers have found that increased microbial counts can be obtained from recently clipped hides when compared to unclipped hides.

Some scientists have recommended that preslaughter washing of cattle—as part of a multiple intervention programme (including strict sanitary dressing procedures and pre-chill decontamination)—could result in reduced mean TVC and improved shelf life when compared to cattle dressed without any interventions, and lesser attention to practices. However, others have demonstrated that preslaughter washing gave no improvements in carcass microbiology. These researchers had applied faeces inoculated with a marker organism to the rumps of cattle, and then washed the faecal matter off after it had dried. Carcass samples from washed animals showed no statistically significant

reduction in marker organism count when compared with samples from unwashed animals.

There has also been research into dehairing cattle after slaughter using sodium sulphide solution, but again, there was no effect on carcass microbial counts from dehaired bodies. In addition, the skins were difficult to handle because they were soapy and slippery. In a separate study, a combination of sodium sulphide and hydrogen peroxide was used to dehair cattle hides. This was found to significantly reduce TVC, coliform count, *Salmonella* and *E. coli* O157:H7 levels by 5 log₁₀ on hide pieces; however, the results of this study have not been backed up by commercial trials, although chemical dehairing is in use in some commercial plants in the USA. It is important to note that these plants use electrical stun systems that kill the animal, so they can delay sticking until after the dehairing process is complete.

Contamination arising from handling

Food handlers should wear gloves while handling food, and must wash hands regularly. The effect of contamination via food handlers was demonstrated in the 1990s, when Australian researchers looked for *Staphylococcus* on cattle hides and carcasses at three abattoirs. They found the organism on 20–70% of cattle hides, but only on 7–26% of carcasses after hide removal; however, after evisceration, 16–50% of carcasses carried the organism. Furthermore, the hands of the workers were heavily loaded with *Staphylococcus*, suggesting that manual handling was contributing to carcass contamination. When the researchers compared some of the isolates, the organisms from the carcasses after evisceration were mostly genetically similar to the organisms on the workers' hands or those from the skinned carcasses prior to evisceration. The organisms from the cattle hides were different. The researchers observed that the workers did not wear gloves and that their hands were severely abraded and continuously wet. This would have contributed to the likelihood of cross-contamination occurring via manual handling during processing.

More recently, wearing rubber gloves has become common practice, and the activities described in published literature as 'strict sanitary procedures' (two-knife system, regular hand washing, regular rinsing and sanitising of knives and other tools) are also normal procedures in Australian abattoirs. In 2008–9 studies were carried out in a Queensland beef abattoir to assess the relative roles of slaughterline activities in contributing to carcass contamination.

Case Study

Two studies were carried out, one year apart. In the first study, the operations of legging, brisket clearing (also known as 'siding in' or 'flanking') and bunging were evaluated. At each station, Whirlpak® sponge samples were taken from:

- carcass surface before operation begins (300 cm²);
- operators hands before operation (palms and knuckles of both hands—approximately 340 cm²);
- tool before operation (both sides of skinning knives—90 cm²; or air knives—78.5 cm², measured on the equipment used);
- tool immediately after operation (both sides of skinning knives—90 cm²; or air knives—78.5 cm², measured on the equipment used);
- exposed carcass surface (300 cm²).

Table 1: Number of samples out of 30 testing positive for *E. coli* or *Staphylococcus aureus* at each operation

Dressing station	Sample site	<i>E. coli</i> *	<i>Staph. Aureus</i> *
Legging	hide	9	28
	hands before operation	2	8
	knife before operation	0	3
	knife after operation	4	11
	cleared carcass surface	0	2
Brisket clearing	hide	9	23
	hands before operation	4	16
	knife before operation	0	2
	knife after operation	0	5
	cleared carcass surface	0	3
Bunging	carcass before operation	8	7
	hands before operation	3	1
	knife before operation	1	2
	knife after operation	0	2
	cleared carcass surface	2	4
Final	carcass at scales	4	17

* Number of samples positive (total samples = 30)

The carcasses were tagged and tracked to the scale, where a further set of 100 cm² samples were taken from the brisket, rump and flank of the hot carcasses. These final samples from each carcass were pooled for analysis. All samples were analysed for TVC (see figure 2), *E. coli* count and *Staphylococcus aureus* count (see table 1).

For the hide-opening operations, the hide was the most significant potential source of contamination. The hide carried the greatest microbial load, and the greatest numbers and prevalence of both *E. coli* and *S. aureus*; however, there was no correlation between hide TVC at either legging or brisket clearing and the final carcass TVC. At legging and bunging, the exposed tissue of the carcass after the operation had a mean TVC lower than counts on tools and hands at that station. At the final carcass sampling, the mean TVC was 1 log₁₀ greater than that of the cleared tissue after legging or brisket clearing; and was 0.5 log₁₀ greater than the exposed tissue after bunging. Similarly, the final carcass samples were more often contaminated with *E. coli* or *S. aureus* than the exposed tissue samples taken at each dressing station.

The hands of workers can be a source of contamination of carcasses. Improving dressing hygiene through a combination of sanitation of tools, wearing of gloves, and carcass decontamination has been recommended for reducing the microbial load on carcasses. The workers involved in the case study were well-trained, all wore gloves, and used a two-knife system for sanitising their implements. As a result, TVC on hands and implements was low, although at brisket clearing, the mean TVC on hands was 2.24 log₁₀ cfu/cm², compared with 1.65 log₁₀ cfu/cm² on the airknife. At all stations, particularly at legging and brisket clearing, the implements gathered contamination during use; however, the efficacy of the sanitation procedure was variable. In general the sanitation procedure resulted in a reduction in microbial load on the implement of less than 1 log₁₀. At brisket clearing, one instance of sanitation resulted in a reduction of 3.0 log₁₀. Microbial loads were higher after sanitation on nine occasions.

The results suggest that much of the contamination on carcasses is picked up later in the process (after bunging), from other workers or from airborne contamination.

The second study, carried out at the same processor, aimed to investigate operations further down the chain, to see if there were any particular 'hotspots' in processing. In this study, samples were taken from:

- hide before skinning;
- skinned carcass before evisceration;
- carcass following high-level trim;
- carcass following low-level trim;
- carcass following weighing, grading and final inspection, prior to chiller loading;
- carcass following pushing into chill;
- carcass after overnight chilling.

In addition, at evisceration, a sample was taken from approximately 300 cm² of the left and right arm of the worker prior to beginning evisceration, and from each side of the midline cut area of the carcass following completion of the evisceration process.

The results indicated that there is a high standard of hygiene at this plant, and no single dressing activity after skinning stood out as being a significant source of carcass contamination. TVC counts on exposed carcass surface prior to trimming were a maximum of 3.29 log₁₀ cfu/cm² immediately post skinning; and at final inspection ranged from <0.52 to 2.09 log₁₀ cfu/cm². *S. aureus* counts, when present, were less than 1 log₁₀ cfu/cm². The exception could be chiller loading, where an increase in contamination on the flanks was detected, although all staff involved wore rubber gloves and plastic aprons. Chilling decreased the microbial load recovered from rumps and flanks in particular.

Interestingly, the TVC at final inspection was much lower in this study than in the previous one. In the second study, the mean TVC on hot sides was 0.39 ± 0.31 log₁₀ cfu/cm² (range <0.52 to 2.09), compared with 1.54 ± 0.69 log₁₀ cfu/cm² (range 0.42 to 3.42) in the previous project. The incoming load on hides was similar in both studies. This suggests that the processor had already made significant improvements in slaughter hygiene over

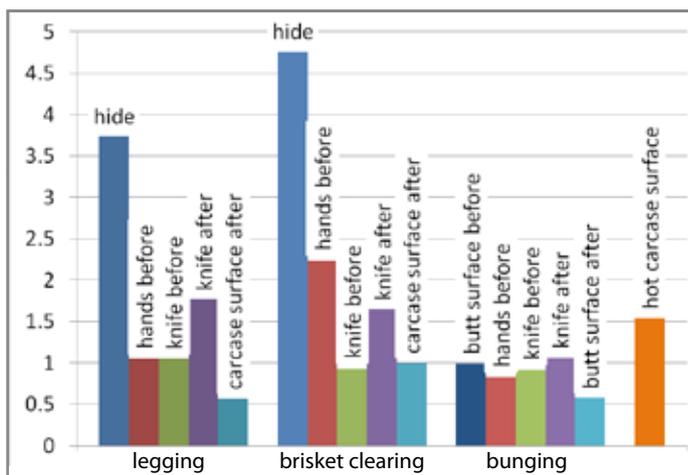


Figure 2: TVC at each dressing station

the preceding 12-month period. The processor commented that they had been focussing on increasing employee commitment to handwashing during processing. This may have contributed to the reduced microbial load on carcasses.

Because the microbial load on cleared tissue immediately after hide opening was very low, it would appear that in this case hide washing or dehairing might not make a significant difference to the microbial load on carcasses. Observations at the plant indicated that the cattle were predominantly Brahman type—with short hair—and were visibly clean and dry. This may well have contributed to the low contamination at hide opening. Furthermore, the operators carrying out the hide-opening process were experienced workers, and took steps to ensure that the hide did not roll in and touch the carcass, and that they themselves did not touch the exposed carcass surface. Attention to personnel practices further along the chain reduced the amount of contamination on the carcasses.

When considering implementing any intervention procedure, it is worth evaluating the process for potential 'high risk' or 'hot-spot' processes. Using microbiological sampling after each operation, a chart (similar to Figure 2), can be drawn up showing where on the line microbial numbers are reduced, remain static, or increase. Then, each step can be assessed for the potential to improve—either by increasing the reduction in microbial numbers, or by preventing increase in numbers. This will allow strategic placement of interventions to address the higher-risk operations.

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

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