BEEF CARCASE HYGIENE IN QUEENSLAND AUSTRALIA – WHERE HIDE CLEANLINESS MAY NOT BE THE BIGGEST ISSUE

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***Abstract*— The hide has long been considered to be the most significant source of contamination to beef carcases, and many countries have implemented hide cleanliness scoring systems or hide washing systems to address this problem. In Queensland, where cattle tend to be very clean and dry, it may be that operator practices are more important, in terms of carcase hygiene, than the hide cleanliness. Qualitative process evaluation has led to some tentative conclusions as to what may constitute a 'good' process, but no published study explores exactly what happens in terms of microbial movement during the individual dressing operations.**

This study aimed to examine the amount of microbial transfer onto the carcase at individual operations, and how much is picked up by the tools and hands of the operator during the operation.

For the skinning operations, the hide was the most significant potential source of contamination, carrying the greatest microbial load. Total Viable Count (TVC) on hands at legging and brisket clearing were higher than at bunging. TVC on implements was low, and at all stations, particularly at legging and brisket clearing, the implement gathered contamination during use. The efficacy of the sanitation procedure was variable. Increases in microbial load on implements following sanitation were observed on nine occasions during the study.

Final carcase sampling yielded mean TVC 1 $\log_{10}$ cfu/cm² greater than that of the cleared tissue following legging or brisket clearing, and 0.5 $\log_{10}$ cfu/cm² greater than the exposed tissue following bunging. Similarly, the final carcase samples were more often contaminated with *E. coli* or *S. aureus* than the exposed tissue samples taken at each dressing station. This suggests that much of the contamination carried by the completed carcase prior to chilling is picked up later in the process, from other workers or from airborne contamination.

***Index Terms*—dressing, microbiology, personnel, tools.**

I. INTRODUCTION

In modern meat production, the major public health hazards are those associated with microbial contamination of the carcase during processing. The hide of cattle is associated with enormous numbers of micro-organisms, which may include foodborne pathogens such as *Escherichia coli* (*E. coli*) O157 or other STEC, *Salmonella enterica* or *Campylobacter* spp. During slaughter and dressing, the skin is removed through a series of steps involving manual cutting and handling of the skin, and there are ample opportunities for microorganisms to be transferred from the outer surface of the skin to the carcase surface. Once the skin is removed, the carcase must be eviscerated and trimmed to specification, once more through a series of steps involving cutting and manual handling of the carcase. Measures are taken to minimise leakage of gut content during evisceration, but each handling of the carcase is another opportunity for micro-organisms to be transferred onto the carcase, and for micro-organisms to be transferred from carcase to carcase through cross-contamination.

Research has shown that using good hygienic practices on the slaughter line results in lower microbial counts on carcasees, but these studies have compared systems using relatively poor practices with those using combinations of animal washing, sterile gloves, face masks and strict knife sanitation at all stations, and only considered the end-product. Other studies have shown that skinning is a high-impact phase for carcase contamination, and that post-evisceration handling increases the microbial load on carcasees. Baseline studies on carcase microbiology in Australian plants have identified that there is a wide range in the microbiological status of carcases produced at different plants. Attempts have been made to identify why this occurs, and understand the factors leading to this variation, through the use of qualitative process evaluation. These have led to some tentative conclusions as to what may constitute a 'good' process, but no published study explores exactly what happens in terms of microbial movement during the individual dressing operations.

This study aims to examine the amount of microbial transfer from the initial surface to the carcase at individual operations, and how much is picked up by the tools and hands of the operator during the operation. By understanding

the dynamics of cross-contamination at the individual operation, it may be possible to identify the relative importance of particular components of the operation, such as manual handling versus implement, and give recommendations as to which good practice (the wearing of gloves, or a particular system of implement or hand/arm sanitation) would give the greater impact on carcase hygiene.

II. MATERIALS AND METHODS

All samples were collected during a single week at an abattoir in Queensland, Australia. At each of legging, brisket clearing (also known as 'siding in' or 'flanking') and bunging, whirlpak ® sponge samples were taken from:

- surface before operation begins (300 cm^2)
- operators hands before operation (palms and knuckles of both hands – approximately 340 cm^2, measured on the operators)
- tool before operation (both sides of skinning knives - 90 cm^2 ; or air knives – 78.5 cm^2, measured on the equipment used)
- tool immediately after operation (both sides of skinning knives - 90 cm^2 ; or air knives – 78.5 cm^2, measured on the equipment used)
- exposed carcase surface (300 cm^2)

Samples were taken in groups of 5 carcase sets. The carcases were tagged and tracked to the scale, and a further set of samples were taken from a 100cm^2 area from each of brisket, rump and flank. These were pooled for analysis (total area 300 cm^2).

Immediately after collection, the sponges were returned to the laboratory for processing. 90mL of peptone water was added to each sponge (which had been rehydrated prior to sampling with 10ml saline), and the sponge vigorously massaged by hand for 30 seconds. A decimal dilution series was made from each sample, and plated onto Petrifilm Aerobic®, Petrifilm E. coli® and Petrifilm Staph Express®. The Petrifilm E. coli® and Petrifilm Staph Express® were incubated at 37°C ± 1°C for 24 hours, and the Petrifilm Aerobic ® at 25°C for 72 hours.

Data gathered was entered into an Excel spreadsheet. Aerobic counts (TVC) per square cm and the prevalence of *E. coli* and *Staphylococcus aureus* were calculated for each sample. Pearson's coefficient of correlation was calculated using MINITAB software.

III. RESULTS

A. Microbial load on hot carcase

Final carcase results are reported first, as all other results will be compared against these. The mean TVC on hot sides was 1.54 ± 0.69 $\log_{10}$ cfu/cm^2 (range 0.42 to 3.42). Four samples yielded *E. coli*, and 17 *S. aureus*. When present, *E. coli* levels were up to 0.67 cfu/cm^2 (detection limit 0.33), and *S. aureus* up to 1.12 $\log_{10}$ cfu/cm^2 (mean 0.06 $\log_{10}$ cfu/cm^2, detection limit 0.33 cfu/cm^2).

B. Legging operation

The mean TVC on the hide prior to opening the first leg was 3.74 ± 0.66 log10 cfu/cm^2 (range 2.85 to 6.28 log10 cfu/cm^2). The hands prior to beginning the operation were 1.05 ± 0.72 log10 cfu/cm^2 (range -0.53 to 2.99 log10 cfu/cm^2) and the clearing knife prior to use was 1.05 ± 0.52 log10 cfu/cm^2 (range 0.05 to 2.00 log10 cfu/cm^2). After use, the mean TVC on the clearing knife was 1.77 ± 0.80 log10 cfu/cm^2 (range 0.34 to 2.87 log10 cfu/cm^2). The TVC of the cleared tissue after legging was 0.57 ± 0.69 log10 cfu/cm^2 (range -0.48 to 1.75 log10 cfu/cm^2).

At the legging station, *E. coli* was found on the hide of nine carcases, at levels of up to 2.52 log10 cfu/cm^2. Two hand samples at legging yielded *E. coli* (-0.53 and -0.23 log10 cfu/cm^2), and four samples taken from the clearing knife after use (mean count 0.28 log10 cfu/cm^2 when present, range 0.05 to 1 log10 cfu/cm^2). No *E. coli* were detected on the knife prior to use or from the cleared tissue after legging was completed.

High numbers of *S. aureus* were present on the hides of carcases. At legging, 28 hides yielded *S. aureus*, at levels of up to 4.23 log10 cfu/cm^2 (mean 2.06 log10 cfu/cm^2). *S. aureus* was also found on 8 hand samples at legging (up to 1.51 log10 cfu/cm^2, mean -0.06 log10 cfu/cm^2). Three samples from the knife before legging were positive (all 0.05 log10 cfu/cm^2), and 11 from the knife after (mean 0.36 log10 cfu/cm^2, maximum 1.09 log10 cfu/cm^2), while only 2 samples from the cleared tissue post legging yielded *S. aureus* (0.30 and 0.00 log10 cfu/cm^2).

C. Brisket clearing operation

At brisket clearing, the mean TVC on the hide prior to opening was 4.76 ± 0.84 log10 cfu/cm^2 (range 3.37 to 7.01 log10 cfu/cm^2). The hands prior to beginning the operation had a higher load than at legging, 2.24 ± 0.73 log10 cfu/cm^2 (range 0.93 to 4.01 log10 cfu/cm^2) and the airknife prior to use was 0.93 ± 0.50 log10 cfu/cm^2 (range 0.41 to 2.38 log10 cfu/cm^2). After use, the mean TVC on the airknife was 1.65 ± 1.07 log10 cfu/cm^2 (range 0.41 to 3.95 log10 cfu/cm^2). The TVC of the exposed tissue after brisket clearing was 1.00 ± 0.87 log10 cfu/cm^2 (range -0.48 to 2.90 log10 cfu/cm^2).

At brisket clearing, *E. coli* was again detected on the hides of nine carcases, counts of up to 2.43 log10 cfu/cm²; and from four hand samples, counts of up to 0.17 log10 cfu/cm². No *E. coli* were detected on any knife sample or from cleared tissue at brisket clearing.

In terms of *S. aureus*, two samples from the airknife before use (0.11 and 0.41 log10 cfu/cm²), five after use (mean 0.43, maximum 0.707 log10 cfu/cm²) and three samples from the cleared brisket (one at 0.67 and two at -0.47 log10 cfu/cm²) were positive. At brisket clearing, 23 hides yielded *S. aureus*, at levels of up to 4.36 log10 cfu/cm² (mean 2.47 log10 cfu/cm²), as did 16 hand samples at brisket clearing (up to 2.37 log10 cfu/cm², mean 0.44 log10 cfu/cm²).

D. Bunging operation

The mean TVC on the perineal tissue prior to beginning bunging was 0.99 ± 0.62 log10 cfu/cm² (range 0.12 to 2.60 log10 cfu/cm²). The hands prior to beginning the operation were 0.83 ± 0.37 log10 cfu/cm² (range -0.23 to 1.61 log10 cfu/cm²) and the knife prior to use was 0.92 ± 0.44 log10 cfu/cm² (range 0.35 to 1.87 log10 cfu/cm²). After use, the mean TVC on the knife was 1.06 ± 0.61 log10 cfu/cm² (range 0.05 to 2.00 log10 cfu/cm²), while the TVC of the exposed tissue in the pelvic inlet was 0.58 ± 0.45 log10 cfu/cm² (range -0.48 to 1.61 log10 cfu/cm²).

E. coli were detected on the perineal tissue of eight carcases immediately prior to bunging, at levels up to 1.32 log10 cfu/cm², from four hand samples at levels of up to 2.43 log10 cfu/cm², and from one knife sample (0.83 log10 cfu/cm²) prior to beginning bunging. No *E. coli* were detected on the bunging knife after the operation was completed, while two samples taken from the exposed tissue at the pelvic inlet yielded *E. coli* (-0.18 and -0.48 log10 cfu/cm²).

S. aureus was detected on the perineal tissue of seven carcases at bunging (mean -0.37 log10 cfu/cm², maximum 0.301 log10 cfu/cm²), on a single hand sample (-0.23 log10 cfu/cm²), on two each of knife before (both 0.05 log10 cfu/cm²) and knife after (0.05 and 1.05 log10 cfu/cm²) samples, and on four samples from the pelvic inlet after bunging (mean -0.16 log10 cfu/cm², maximum 0.00 log10 cfu/cm²).

E. Efficacy of implement sterilisation

The mean reduction in TVC achieved by implement sanitisation was 0.59 log10 cfu/cm² overall. At legging the maximum reduction was 1.90 log10 cfu/cm², the minimum a 1.43 log10 cfu/cm² increase, and the mean reduction 0.79 log10 cfu/cm². At brisket clearing, the maximum reduction was 3.00 log10 cfu/cm², the minimum a 0.52 log10 cfu/cm² increase, and the mean reduction 0.84 log10 cfu/cm². At bunging, the maximum reduction achieved was 1.52 log10 cfu/cm², the minimum a 1.09 log10 cfu/cm² increase and the mean reduction 0.15 log10 cfu/cm². Increases in microbial load were seen on 5 of 24 occasions at legging, 4 of 24 occasions at brisket clearing and one of 14 occasions at bunging.

IV. DISCUSSION

For the skinning operations, as expected, the hide was the most significant potential source of contamination, carrying the greatest microbial load, and the greatest numbers and prevalence of both *E. coli* and *S. aureus*. This supports previous work on beef dressing practices (Hudson et al., 1998, Bell, 1997, Elder et al., 2000, Stolle, 1981, Roberts et al., 1984). Newton et al. (1978) suggested that final carcase counts are an almost constant fraction of those on hides (0.3%), which was broadly agreed by Vivas-Alegre and Buncic in 2004, although those authors found that this fraction differed between abattoirs (Vivas Alegre and Buncic, 2004). However, the present study found no correlation between hide TVC at either legging or brisket clearing and the final carcase TVC.

Previous authors have suggested that the hands of workers can be a source of contamination for carcases (Pether and Gilbert, 1971), and improving dressing hygiene through a combination of strict sanitation of tools, wearing of gloves and carcase decontamination has been recommended for reducing the microbial load of carcases (Graves-Delmore et al., 1998, Gill and Jones, 2002, Chandran et al., 1986, Bacon et al., 2000). The workers involved in the present study all wore rubber gloves, and used a two-knife system for sanitising their implements, with sterilisers running at 82°C. As such, TVC on hands and implements were 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 implement gathered contamination during use, as to be expected. 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, although at brisket clearing, one instance of sanitation resulted in a reduction of 3.0 log10. Increases in microbial load following sanitation were observed on nine occasions during the study.

At legging and bunging, the exposed tissue of the carcase following the operation had mean TVC lower than any other sample taken at that station. At brisket clearing, the mean TVC on the cleared brisket was the same as that on the knife before use. Final carcase sampling yielded mean TVC 1 log10 greater than that of the cleared tissue following legging or brisket clearing, and 0.5 log10 greater than the exposed tissue following bunging. Similarly, the final carcase samples were more often contaminated with *E. coli* or *S. aureus* than the exposed tissue samples taken at each dressing station.

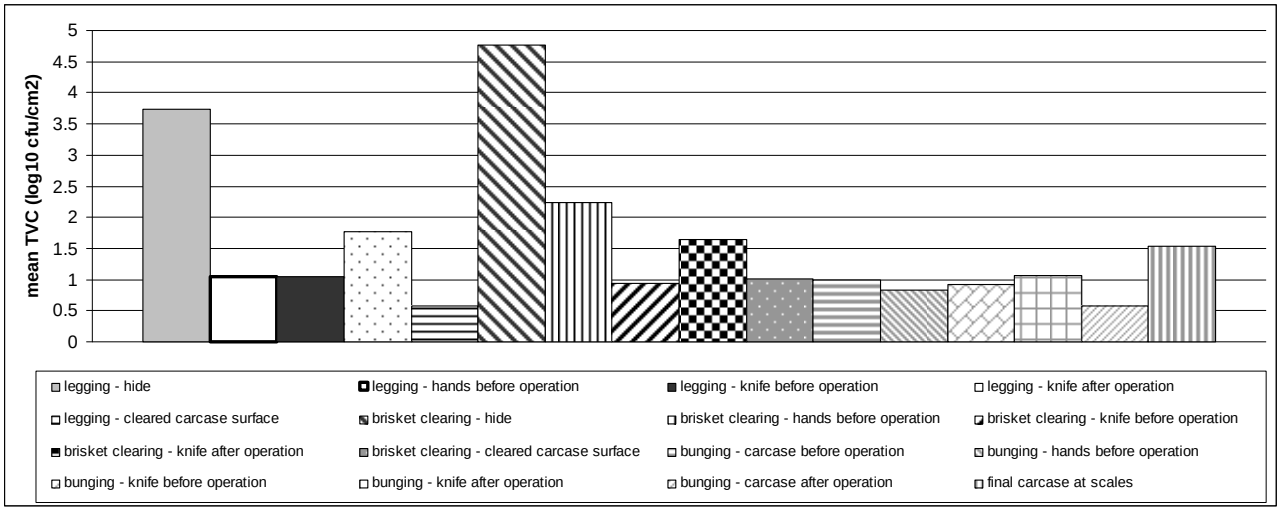

Figure 1: Mean TVC at each sample point

IV. CONCLUSION

The results suggest that much of the contamination carried by the resultant carcase is picked up later in the process, after bunging, from other workers or from airborne contamination.

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