An alternative process for cleaning knives used on meat slaughter floors

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Abstract

Traditionally on slaughter floors operator knives are cleaned by rinsing in hand wash water at 20-40°C followed by brief immersion in baths termed "sterilisers" which contain water no cooler than 82°C. Under Australian legislation, both domestic and export, it is possible for a meat processing establishment to apply to the Controlling Authority for permission to implement an alternative procedure providing that it is at least the equivalent of the legislated one. No scientific reasoning exists for the 82°C requirement and the possibility of replacing this element of the knife cleaning procedure with an alternative procedure using 60°C water and a longer immersion time was investigated at an abattoir slaughtering cattle and sheep. Knives were tested at a range of work stations located along the beef and mutton slaughter floors for Total Viable Counts (TVCs) and *E. coli*. For knives used on the beef chain the mean log TVC/cm^2 was 2.18 by the current knife cleaning process and 1.78 by the alternate procedure ($p<0.001$). Using the current system *E. coli* was isolated from cleaned knives on 20/230 (8.7%) occasions compared with 21/230 (9.1%) occasions using the alternative system. The mean log *E. coli* of positive knives was 0.43/cm^2 and 0.61/cm^2 from the current and alternative systems, respectively. On the mutton chain the mean log TVC/cm^2 was 1.95 using the current knife cleaning process and 1.69 by the alternative procedure ($p=0.014$). Using the current system *E. coli* was isolated from cleaned knives on 24/130 (18.5%) occasions compared with 29/130 (22.3%) occasions using the alternative system. The mean log *E. coli* of positive knives was 0.90/cm^2 and 0.76/cm^2 from the current and alternative systems, respectively.

Keywords: Meat industry; knife cleaning; alternative procedure; Australian Standard; equivalence; operator safety

1 Introduction

It is a traditional part of the slaughter and dressing process for operators and inspectors to clean their knives by first rinsing in tepid (20-40°C) water to remove soil and particles then to dip them in water maintained no cooler than 82°C. This procedure is done between carcases with the aim of preventing cross contamination between bodies. Baths termed "sterilisers" are supplied for knife cleaning at each work station. Prior to metrication in Australia, water in sterilisers was required to be no cooler than 180°F – this temperature was subsequently converted to 82°C; however, the scientific underpinning for this requirement is unclear.

A number of opinions may be found in the literature for suitable conditions for knife and equipment sanitation. Some authors suggested that water for equipment cleaning should be heated to 140°F for one minute or to 130°F for 5 minutes (Collins, 1954; Empey and Scott, 1939). Collins (1954) further stated that knives and saws should be replaced and subjected to immersion in alkali at 160-180°F after twelve carcases have been processed. Another statement is that the circular saw used for carcase splitting must be periodically wiped clean of all visible blood and sawdust.

In the 1950s Dr Sloan, working for the USDA Agricultural Research Service (ARS) in Beltsville, Maryland, is believed to have investigated methods of sterilising carcass-splitting saws. Sloan found that dipping carcase-splitting saws in 180°F water killed sufficient numbers of organisms to satisfy regulatory requirements. An alternative is that water at 82°C may have been chosen as the knife sterilisation procedure that would kill the tubercule micro-organism *Mycobacterium tuberculosis*, the primary target organism in milk and other foods at that time (Brewer, R., USDA, personal communication March 2002). Eventually 180°F water became the global standard for knife cleaning in all slaughter floor operations.

Recently, it has become possible under the Australian Standard for the Hygienic Production and Transportation of Meat and Meat Products for Human Consumption (AS 4696: 2002) and the Export Control (Meat and Meat Products) Orders for a meat processing establishment to apply to the Controlling Authority for permission to implement an alternative procedure. Such an application must provide scientific data to indicate the alternative procedure is at least equivalent to the one regulated.

As a precursor to the present study, Midgley and Eustace (2003) monitored the effect of cleaning knives in lukewarm hand wash water then in sterilisers containing water cooler than 82°C. Inactivation was of the same order as that obtained by momentary dipping in 82°C water and the researchers recommended that in-plant trials be conducted using steriliser temperatures cooler than 82°C.

It was against this background that rinsing in hand wash water coupled with a two-knife system and 60°C water was evaluated as an alternative procedure to the current system which involves rinsing then momentary dipping of the knife in 82°C water. Under the alternative system each operator was provided with two knives with, at any one time, one knife in use on the carcase and the other immersed in water at 60°C. The temperature of immersion water (60°C) was selected arbitrarily by abattoir management as one which, if it could provide an equivalent outcome to 82°C water, would be advantageous for economic and operator safety reasons. The evaluation was carried out according to a design in which, when the alternative system was being trialled, knives always received a final treatment with 82°C water before being used on carcases.

2. Materials and Methods

2.1 Knife cleaning methods

The present study was carried out in an establishment with separate slaughter and dressing floors for cattle and sheep, typical daily volumes for which were 500 and 3,000 head, respectively. Two regimes were investigated for cleaning of knives. Under the current system the knife was cleaned by rinsing in hand wash water at 20-40°C followed by momentary dipping in a "steriliser" maintained no cooler than 82°C. Under the alternative cleaning regime a two-knife system of knife cleaning was used with rinsing as before, followed by immersion in water at 60°C for the period while the other knife was used on the carcase, the operator exchanging knives between carcases. A portable steriliser containing a thermostatically controlled heating element (Ratek TH1 thermoregulator) was used to maintain a temperature at 60°C. A data logger was placed in the steriliser to record water temperature during use.

2.2 Sponge sampling of knives

Knife blades were sampled immediately after the operator had cleaned the knife by one of the methods above using a sterile polyurethane sponge (Nasco Whirlpak) hydrated in 25mL of 2 % (w/v) buffered peptone water. The sponge was doubled over the back of the knife and the blade wiped from handle to tip. A protective glove was worn by the operator beneath the rubber glove to protect against knife-cut wounds. Ten knives at each station were tested, five knives in each of two trials.

2.3 Transportation of samples to the laboratory

After sampling, sponges in sterile bags were taken to the onsite laboratory for testing. In the laboratory, samples were held in a refrigerator until analysed.

2.4 Determination of Total Viable Count (TVC) and E. coli

The sponge was squeezed firmly through the plastic bag and, from the liquid expressed, serial dilutions were prepared in 0.1% buffered peptone water blanks (9 mL). Aliquots (1 mL) from each dilution were spread on either Aerobic Plate Count Petrifilm (3M) and incubated at 20-25°C/3 days or on *E. coli/*Coliform Petrifilm (3M) and incubated at 37^{o}C for 2 days. Colonies were identified and counted as per the manufacturers instructions.

2.5 Statistical analysis

When *E. coli* was absent from Petrifilms the result was entered as "not detected". TVCs were converted to $\log_{10}$ cfu/cm^2 and the mean of the $\log_{10}$ cfu/cm^2 was calculated. The effects of the current and alternative methods were compared using an Analysis of Variance. All calculations were performed with the statistical software R (R Development Core Team 2005). The limit of detection for both TVC and *E. coli* was 0.36 cfu/cm^2.

3 Results

Knives were tested at a range of stations located along the beef and mutton slaughter floors and *E. coli* and Total Viable Counts (TVCs) obtained. In Table 1 are presented TVCs and *E. coli* prevalence on knives used at stations along the beef chain. The overall mean log TVC/cm^2 was 2.18 by the current knife cleaning process and 1.78 by the alternative procedure. This constituted a significant overall difference in average log TVC/cm^2 (P-value < 0.001). However, this reduction was not consistent for each work station and significantly larger falls were observed at tongue drop, head inspection and head boning stations, but no significantly higher average log TVC/cm^2 were observed with the alternate procedure at any of the 23 work stations. In general, higher TVCs occurred earlier in the process, when cuts were made through the hide particularly when air knives were used, or when knives were used at the head stations. Using the current system *E. coli* was isolated from cleaned knives on 20/230 (8.7%) occasions compared with 21/230 (9.1%) occasions using the alternative system. The mean log *E. coli* of positive knives was 0.43/cm^2 and 0.61/cm^2 from the current and alternative systems, respectively.

In Table 2 are presented TVCs and *E. coli* prevalence on knives used at stations along the mutton chain. The mean log TVC/cm^2 was 1.95 by the current knife cleaning process and 1.69 by the alternate procedure. This constituted a significant overall difference in average log TVC/cm^2 (P-value = 0.014). However, this reduction was not consistent for each work station and significantly larger falls were observed at the forequarter, pluck removal and pluck table stations, but no significantly higher average log TVC/cm^2 were observed with the alternative procedure at any of the 13 work stations. Higher TVCs were associated with knives used to incise the brisket, trim exposed neck tissue, ring the bung (incise the anus) and remove the viscera. Using the current system *E. coli* was isolated from cleaned knives on 24/130 (18.5%) occasions compared with 29/130 (22.3%) occasions using the alternative system. The mean log *E. coli* of positive knives was 0.90/cm^2 and 0.76/cm^2 from the current and alternative systems, respectively.

4 Discussion

Midgley and Eustace (2003) demonstrated the effectiveness of an alternative procedure involving the combined effects of rinsing the knife in hand-wash water prior to immersing it for 15 s at 72°C. These researchers showed that, before they were washed, knives from the first leg and head stations were more highly contaminated than were those from other stations (Table 3). The highest *E. coli* contamination was at the first leg station, where the knife is often in contact with the hide during hide removal. When knives were washed in hand-wash water (20-40°C) only, there were reductions in TVCs of around 0.7 $\log_{10}$ cfu/cm^2 and the prevalence of *E. coli* fell from 50% to 24%. After pre-washing, immersion of the knives in water at 72°C/15s or 82°C/1s effected further reductions of 0.5 $\log_{10}$ in TVC and to 8.3% in the prevalence of *E. coli*.

The present study extends the work of Midgley and Eustace (2003) and has, for the first time to our knowledge, established a microbiological baseline for knives used along the entire beef and mutton chains after the process termed “sterilising” (momentary dipping the knife in 82°C water). It is generally accepted by microbiologists that this term is a misnomer with “cleaning” or “sanitising” more appropriate descriptors. The present study indicates that faecal organisms are not always removed during knife cleaning and that persistence of such organisms is related to the microbial load on the knife prior to cleaning. Thus knives used for “dirty” operations such as incising areas of the hide/pelt which have faecal contamination, or freeing the anus, are more likely to bear *E. coli* and to have TVCs >100/cm^2 after the brief immersion at 82°C.

Contemporaneously with the present study a separate investigation of knife cleaning was undertaken at an Australian pig slaughter and dressing facility. In Table 4 are presented TVCs and *E. coli* prevalence on knives cleaned by momentary immersion in 82°C water at some stations along a pig slaughter chain (provided by Reyes-Veliz, personal communication). The mean log TVC/cm^2 was 1.98 with higher TVCs on knives used to remove singed hairs (polishing) and at the backing off (incising to the backbone) stage. *E. coli* was isolated from cleaned knives on 7/30 (23%) occasions and the mean log *E. coli* of positive knives was 0.25/cm^2.

Similar loadings on cleaned knives were found by Bell and Hathaway (1996) and Bell (1997) during sheep and beef processing, respectively, in New Zealand abattoirs (Tables 5 and 6). Bell and Hathaway (1996) measured the effect of knife cleaning at the work station where opening cuts on the hind leg of lamb carcases are made. Before cleaning knives had a mean log TVC/cm^2 of 5.04, reflecting the heavy soiling which can occur at this site on the fleece. Rinsing the knife in hand wash water at 44°C removed 98.2% of contamination (1.8 log reduction) from the blade and, after subsequent dipping in 82°C water, 99.8% of contamination was removed to effect a 2.6 log reduction (Table 5). On the beef floor Bell (1997) found contamination on knife blades approximated that of the hide on the hind legs (mean log TVC/cm^2 of 3.61). Cleaning the knife by rinsing in hand wash water then dipping in 82°C water reduced the loading on the blade to mean log 2.64/cm^2 – a 1 log reduction. The studies of Bell and Hathaway (1996) and Bell (1997) are also of interest because they indicate that the knife hand was generally one log scale more contaminated than the knife blade, both before and after cleaning.

The results of Bell and Hathaway (1996) indicate that most of the reduction in bacteria is attributable to the spray rinse. Similarly, Midgley and Eustace (2003) found that rinsing the knives under streams of wash-water before immersing in a steriliser removed at least 70% of bacteria. Importantly, thermal inertia of the equipment prevents surfaces attaining the water temperature until several seconds have elapsed (Lowry, 1991) and Peel and Simmons (1978) showed that momentary immersion of knives at 82°C, on its own, was ineffective in decontaminating knives of *Salmonella*. When fats or proteins are present on them, immersion of knives at 82ºC for as long as 10 s will not give satisfactory reduction in bacterial contamination (Snidjers et al., 1985). Also, hot water at 82°C was found to fix proteins onto the surface of the equipment (Weise and Levetzow, 1976; Schütt-Abraham et al*.*, 1988) leading to possible entrapment of bacteria. Midgley and Eustace (2003) recommended a lower temperature and longer immersion time – a treatment that is possible where a 2-knife rotation system is practised.

In an alternative system used in the present project, rinsing knives in hand wash water was followed by a 2-knife system with 60°C water so that knives had a longer residence time. Residence time varied according to work station from more than 30 seconds at legging on the beef floor to 1-2 seconds at the heads off and wax eyes (teats removal) station on the mutton floor (data not included). On the beef floor, prevalence of *E. coli* was similar for both cleaning systems (8.7% for the current *versus* 9.5% for the alternative system) and the mean log TVC was lower ($p < 0.001$) using the alternative system (1.78 *versus* 2.18/cm^2). On the mutton floor mean log TVCs were 1.95 for the current and 1.69 alternative knife cleaning systems ($p = 0.014$). However, prevalence of *E. coli* was higher using the alternative system (22.3% versus 18.5%). This difference may reflect differences in lots being processed (and therefore, the knife loadings pre-cleaning).

From the current study it can be concluded that, after rinsing the knife in hand wash water, using two knives and cleaning them in 60°C water provides a process equivalent to momentary dipping in 82°C water. Midgley and Eustace (2003) listed potential benefits from using temperatures cooler than 82°C for cleaning knives including:

- Reduced risk of operator injury through scalding
- Reduced hot water consumption during knife and equipment cleaning
- Reduce impact of hot water on effluent treatment
- Reduced fogging and condensation
- Potential reduction in maintenance requirements

A change to 60°C water and its impact on improved occupational health and safety should not be underestimated. It is thought that burns from steriliser water may account for around 10% of all industrial injuries in an abattoir and limiting the amount of 82°C water would improve safety of operators.

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Table 1: *E. coli* and TVCs of knives cleaned in 82°C water (current system) and in 60°C water (alternative system) using a 2-knife system on the beef floor

Station	E. coli*		Mean log TVC/cm^2 (SD)	
	Current system	Alternative system	Current system	Alternative system
Halal cut	1	0	1.49 (0.23)	1.99 (0.61)
Weasand tie	4	2	2.77 (0.32)	2.53 (0.90)
Sticking	0	0	2.34 (0.73)	2.01 (0.94)
Rinsing	0	0	1.91 (0.22)	2.03 (0.42)
Scalping	0	1	1.56 (0.59)	1.83 (1.12)
1st leg	1	1	1.64 (1.09)	1.11 (0.65)
2nd leg	0	0	1.72 (0.13)	1.51 (0.95)
Air knife 1	1	2	2.33 (1.22)	1.66 (0.40)
Air knife 2	4	2	3.44 (0.09)	2.51 (0.39)
Air knife 3	1	6	2.31 (0.66)	1.98 (0.57)
Air knife 4	1	0	2.21 (0.78)	2.25 (0.28)
Tongue drop	1	1	3.85 (0.00)	1.73 (0.48)
Heads Inspection	0	0	3.85 (0.00)	1.19 (0.81)
Head Boning	1	0	3.48 (0.16)	1.29 (0.44)
Bung drop	0	0	2.35 (1.64)	2.27 (0.47)
Evisceration	3	0	1.35 (0.29)	0.94 (0.64)
Viscera inspection	1	2	1.48 (1.06)	1.54 (0.72)
Fronts inspection	0	0	1.77 (0.55)	1.64 (0.49)
Separate runners	0	2	1.54 (0.58)	1.87 (0.92)
Neck trim	0	0	1.70 (0.37)	1.87 (0.97)
Whizard knives	0	0	1.90 (0.55)	1.03 (0.35)
Backs inspection	1	2	1.95 (0.15)	2.03 (0.63)
Backs trim	0	0	1.14 (0.63)	2.17 (0.82)
Totals and means	20/230	21/230	2.18 (0.99)	1.78 (0.79)

*Number of knives testing positive for *E. coli* out of 10 knives sampled at each station

Table 2: *E. coli* and TVCs of knives cleaned in 82°C water (current system) and in 60°C water (alternative system) using a 2-knife system on the mutton floor

Station	E. coli*		Mean log TVC/cm^2 (SD)	
	Current system	Alternative system	Current system	Alternative system
Sticking	0	0	0.73 (0.74)	1.46 (0.56)
Briskets	2	4	2.13 (0.94)	2.04 (0.24)
Forequarters	1	0	2.46 (1.33)	1.24 (0.34)
Heads off	1	0	2.03 (1.08)	2.14 (0.71)
Wax eyes	0	1	1.07 (0.59)	1.69 (0.92)
Tail trim	3	6	1.70 (1.36)	2.10 (0.58)
Neck trim	0	0	2.07 (0.63)	2.17 (0.41)
Bung drop	6	9	1.83 (1.39)	2.09 (0.73)
Pluck removal	3	2	2.02 (0.19)	1.01 (0.57)
Evisceration	4	2	1.81 (0.77)	1.28 (0.58)
Viscera inspection	1	3	2.41 (0.90)	1.87 (0.58)
Separate runners	1	2	1.95 (0.73)	1.62 (0.46)
Pluck table	2	0	3.12 (0.22)	1.20 (0.51)
Totals and means	24/130	29/130	1.95 (1.01)	1.69 (0.68)

* Positive/Total knives tested out of 10 knives tested at each station

Table 3: *E. coli* and TVCs of knives before during and after cleaning and sanitising[1]

Station	Before washing		After washing/before dipping in 72°C water/15s		After dipping in 72°C water/15s	
	E. coli [2]	TVC [3]	*E. coli* [4]	TVC [3]	*E. coli* [2]	TVC [3]
First leg	10	2.81 (0.69)	13	2.43 (0.48)	3	1.79 (0.73)
Heads boning	8	3.05 (0.39)	8	2.03 (0.69)	0	1.24 (0.83)
Evisceration	4	1.81 (0.71)	0	0.93 (0.96)	0	0.78 (0.73)
Backs Trim	2	1.47 (0.89)	2	1.14 (0.91)	1	0.44 (0.94)
Totals and means	24/48	2.28 (0.94)	23/96	1.62 (0.99)	4/48	1.06 (0.94)

[1] From data of Midgley and Eustace (2003)
[2] Number positive for *E. coli* out of 12 knives sampled at each station (3 on each of 4 different occasions)
[3] Log/cm^2 (SD)
[4] Number positive for *E. coli* out of 24 knives sampled at each station (3 on each of 8 different occasions)

Table 4: *E. coli* and TVCs of knives cleaned in 82°C water on a pig slaughter floor (Reyes-Veliz pers. comm.)

Station	*E. coli**	Log TVC/cm^2 (SD)
Shaving	5	3.46 (0.29)
Bung and testes	0	1.65 (0.82)
Gutting	1	0.64 (0.31)
Trotter removal	1	1.15 (0.64)
Backing off	0	3.52 (0.18)
Final trim	0	1.49 (0.99)
Totals and means	7/30	1.98 (1.26)

* Positive/Total knives tested

Table 5: TVCs of knife blades before and after cleaning by rinsing in warm water then immersion in 82°C water on a sheep slaughter floor (after Bell and Hathaway, 1996)

Treatment	Mean log TVC/cm^2 (SD)	
	Before treatment	After treatment
44°C spray rinse (n=50)	5.04 (0.41)	3.29 (0.68)
44°C spray rinse then 82°C immersion (n=50)	5.04 (0.41)	2.42 (0.65)

Table 6: TVCs of knives before and after cleaning in 82°C water on a beef slaughter floor (after Bell, 1997)

Station	Mean log TVC/cm^2 (SD)	
	Before cleaning	After cleaning
Knife hands (n=20)	4.74 (0.67)	3.73 (0.42)
Knife blades (n=20)	3.61 (0.47)	2.64 (0.44)