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Contamination of Beef Carcasses during Hide Removal and use of a Test Bacterial Decontamination System on Beef Hide

The National Food Centre

RESEARCH & TRAINING FOR THE FOOD INDUSTRY

RESEARCH REPORT NO 25

Contents

CONTAMINATION OF BEEF CARCASSES DURING HIDE REMOVAL AND USE OF A TEST BACTERIAL DECONTAMINATION SYSTEM ON BEEF HIDE

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PART 1: CONTAMINATION OF BEEF CARCASSES DURING HIDE REMOVAL

Summary

The Abattoirs Act, 1988 (Veterinary Examination) (Amendment), 1998 (S.I. No. 6, 1998) empowers the *ante mortem* veterinary inspector to reject animals for slaughter if the condition of the hide, as a consequence of visible contamination, is such as to increase the risk of cross contamination of the carcass during dressing procedures. Using pictorial and written guidelines, cattle in lairage are placed in categories from 1 (clean) to 5 (very dirty) depending on the amount of visible hide contamination. Initially, category 5 animals were rejected for slaughter and category 4 animals were slaughtered under special conditions, including reduced line speed, increased space between the animals and increased use of workstation hygiene facilities. Categories 1-3 are processed as normal. Currently, categories 4 and 5 are rejected for slaughter. However, most abattoirs shave off accumulated faeces (faecal clods) to enable rejected animals to meet the required cleanliness standard. Prior to the implementation of the cleanliness regulation in Irish abattoirs, this study was carried out to examine the effect of hide cleanliness on carcass contamination and the benefits of increased use of workstation hygiene facilities during de-hiding operations. The survival of *E. coli* O157:H7 in faecal clods was also examined. The main results of this work are:

- At carcass sites where the hide is manually removed, there was a positive relationship between hide cleanliness and carcass contamination. Bacterial total viable counts (TVCs) at the hock were significantly higher on carcasses from category 5 animals than category 2 animals. TVCs at the brisket were significantly higher on carcasses from category 3 and 5 animals than category 2 animals.
- Increasing the use of hygiene facilities (i.e. use of disposable gloves, sterile knife and steel) reduced the extent of contamination at the brisket of category 4 animals.
- *E. coli* O157:H7 remained viable in dry faecal clods for at least 24 days.

INTRODUCTION

The bacterial population on the hide of cattle is derived from soil, water, vegetation and faeces and may include species that are pathogenic to humans such as *E. coli* O157:H7 and *Salmonella*. Bacteria may be transferred to the carcass via contact with the hide or indirectly via contact with workers' hands, clothes, tools and factory equipment during processing, posing health risks to the ultimate consumer.

In recognition of the potentially greater carcass contamination from animals with excessively dirty hides carrying adherent dirt, faeces and straw, the regulatory authorities in a number of countries, including Australia, New Zealand, Finland and the United Kingdom, have instituted regulations designed to prevent the slaughter of excessively dirty cattle. Special hide regulations have been in place in Finland since 1982. The Australian Meat Safety Enhancement Program restricts the slaughter of excessively dirty cattle and educates cattle producers on the importance of clean livestock through its 'Cattlecare' programme. In the United Kingdom, the Meat Hygiene Service has a policy of rejecting excessively dirty cattle based on pictorial and written guidelines.

In Ireland, the Abattoirs Act, 1988 (Veterinary Examination) (Amendment), 1998 (S.I. No. 6, 1998) empowers the *ante mortem* veterinary inspector to reject animals for slaughter or require slaughter under special conditions, based on the level of visible hide contamination. Special conditions for slaughter include reduced line speed, increased space between animals and increased use of workstation hygiene facilities. Since their introduction in Ireland, cattle regulations have become more stringent and at present, both category 4 and 5 animals are rejected. However, a procedure for shaving accumulated hardened faeces (faecal clods) from category 4 and 5 animals has been introduced into most abattoirs, enabling them to reach the cleanliness standard. The potential risk of pathogens surviving in faecal clods on the hide of animals at slaughter is not known.

This study examined:

1. The relationship between livestock cleanliness categories and the amount of contamination on the resultant carcasses.

2. The difference in bacterial contamination on carcasses from category 4 animals dressed without increased use of workstation hygiene facilities and those dressed with increased use of hygiene facilities.
3. The survival of *E. coli* O157:H7 in faecal clods

Process description and selection procedure for cattle cleanliness

The abattoir observed in the study slaughtered cattle (predominantly steers and heifers) at a line speed of 40-80 animals per hour. During hide removal, the hide was manually detached from the hind legs, flank and fore legs before being completely removed by an upward pulling automatic hide puller. Cattle were visually inspected in the lairage and assigned to a category based on the Department of Agriculture, Food and Rural Development, Livestock Cleanliness Categories (DAFRD-LCC) (Table 1). Briefly, this procedure uses pictorial (Figure 1) and written guidelines to place cattle in categories ranging

Table 1: Irish Department of Agriculture, Food, and Rural Development Livestock Cleanliness Categories.

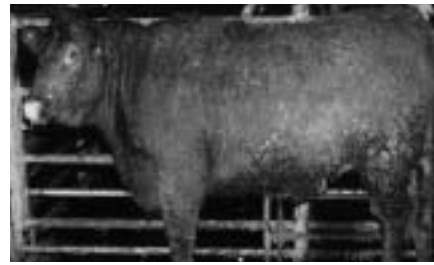
Category	Characteristics
Category 1:	No evidence of adherent faecal material and limited amounts of loose straw/bedding. Animals in this category are accepted for slaughter.
Category 2:	A light covering of dried faecal material and limited amounts of loosely adherent straw/bedding. Animals in this category are accepted for slaughter.
Category 3:	A significant amount of loose straw/bedding/dirt over a large body area. Animals in this category are accepted for slaughter under normal conditions when presented in a dry state.
Category 4:	Heavy amounts of adherent dirt/faeces on fore and hind legs, underside of the abdomen and the lower surface of the ribcage. During dressing, line speed is reduced, additional space is allowed between carcasses and the use of workstation hygiene is increased.
Category 5:	Very heavy amounts of adherent dirt/faeces. Balling of adherent dirt/faeces may be evident on the underside of the abdomen. Animals are rejected for slaughter.

from 1 (very clean) to 5 (very dirty). When it was first implemented the procedure required that category 5 animals were rejected for slaughter while category 4 could be slaughtered under special conditions which required increased use of workstation hygiene facilities and slower line speeds. Cattle assigned in categories 1 - 3 were processed as normal. The procedure has since been modified to exclude both category 4 and 5 animals from slaughter. This

Category 1

Category 2

Category 3



Category 4

Category 5

Figure 1: Pictorial guidelines for Department of Agriculture, Food and Rural Development, Livestock Cleanliness Categories.

study was carried out prior to the implementation of the DAFRD-LCC regulations in Irish abattoirs, hence category 4 and category 5 animals were processed as normal. Cattle were selected in lairage and identified in the slaughter hall by tags attached to hide of the animal. Identity tags were placed on the carcass following de-hiding.

The relationship between the amount of dirt on the hide of animals presented for slaughter and the levels of contamination on the resultant carcasses

The objective was to determine the relationship between hide cleanliness and bacterial numbers on the resultant carcass. Animals from categories 2, 3 and 5 were selected in lairage, labelled and slaughtered. As the study was carried out in February when animals tend to be quite dirty, it was not possible to obtain animals from category 1.
Total viable counts (TVCs) were enumerated on carcasses from cleanliness categories 2, 3 and 5 at the following sites;

Carcass site	**Process stage**
Hock	Following legging.
Brisket	Following complete removal of the hide.
Cranial back	Following complete removal of the hide.
Bung	Following complete removal of the hide.
Inside round	Following carcass splitting.

TVCs at the hock of carcasses from dirty animals (category 5) were higher than on carcasses from cleaner animals (category 2) ($P<0.05$) (Table 2). Similarly, TVCs at the brisket of carcasses from category 3 and 5 animals were higher than on carcasses from cleaner animals (category 2) ($P<0.05$). This finding of a positive relationship between hide cleanliness and bacterial contamination at the hock and brisket is most likely due to the manual skinning of these sites during hide removal. Bacteria may be transferred to these sites directly through contact with the hide or indirectly through contact with operatives' hands, which had previously been in contact with the hide. There were no significant differences between the bacterial counts from

Table 2: Total viable counts (log_{10} cfu cm^{-2}) at different sites on carcasses from cattle graded as category 2, 3 and 5.

Carcass sites	Cleanliness categories 2	3	5
Hock	3.36[a]	3.70[ab]	3.90[b]
Brisket	4.18[a]	4.80[b]	4.71[b]
Cranial back	2.53[a]	2.55[a]	2.68[a]
Bung	2.67[a]	3.16[a]	3.20[a]

Different superscripts within each row denote significant differences (P<0.05).

all other sites on carcasses from category 2, 3 and 5 animals. This is probably due to little or no handling of these sites during hide removal.
These results show a positive relationship between hide cleanliness and carcass contamination at sites subjected to manual skinning.

Bacterial contamination on carcasses dressed without increased use of workstation hygiene facilities and those dressed with increased use of facilities

At the time of this study, Irish regulations stated that animals graded as category 4 were to be slaughtered under special conditions, which included reduced line speed, increased space between animals and an increased use of workstation hygiene facilities. The objective of this study was to compare the bacterial count on carcasses from category 4 animals dressed without increased use of workstation hygiene facilities with those on carcasses from category 4 animals dressed with increased use of hygiene facilities.
Category 4 animals were slaughtered in pairs. During the de-hiding of the first animal of a pair, workers responsible for skinning the hock and brisket sites occasionally rinsed their hands in warm potable water and briefly immersed their knives in the knife sterilisers provided. Steels were not sterilised on a regular basis. Animals processed in this way are referred to as 'without

increased hygiene'. During de-hiding of the second animal of a pair, the operatives responsible for skinning the hock and brisket were provided with disposable gloves and a sterilised knife and steel. Animals processed in this way are referred to as 'with increased hygiene'.

Increased use of hygiene facilities reduced carcass contamination during dehiding (Table 3). The use of disposable gloves, sterile knives and steels by the operatives at hide removal resulted in a reduction in TVCs at the brisket ($P<0.05$).

In contrast to the brisket, TVCs at the hock were not reduced following the use of disposable gloves, sterile knives and steels by operatives at hide removal. This may be due to the level of handling this site receives during removal of the hide and transfer of the animal from the slaughter rail to the dressing rail, negating the effect of the clean practices.

These results show that during hide removal, the extent of cross contamination from the hide to the carcass can be reduced with increased use of hygiene facilities.

Table 3. Bacterial counts at the hock and brisket of carcasses dressed with and without increased hygiene.

	Dressing procedure	
Carcass site	With increased hygiene	Without increased hygiene
Hock	3.90[a]	4.03[a]
Brisket	4.40[a]	4.94[b]

Different superscripts within each row denote significant differences ($P<0.05$).

The survival of *E. coli* O157:H7 in faecal clods

Depending on season and husbandry practices, the hide may be visibly clean or contain varying levels of dirt and faeces. In some cases, accumulated faeces may dry and harden to form faecal clods which are difficult to remove and may contain pathogens. Although *E. coli* O157:H7 may survive in fresh faeces on the hide, its fate in faecal clods is unknown.

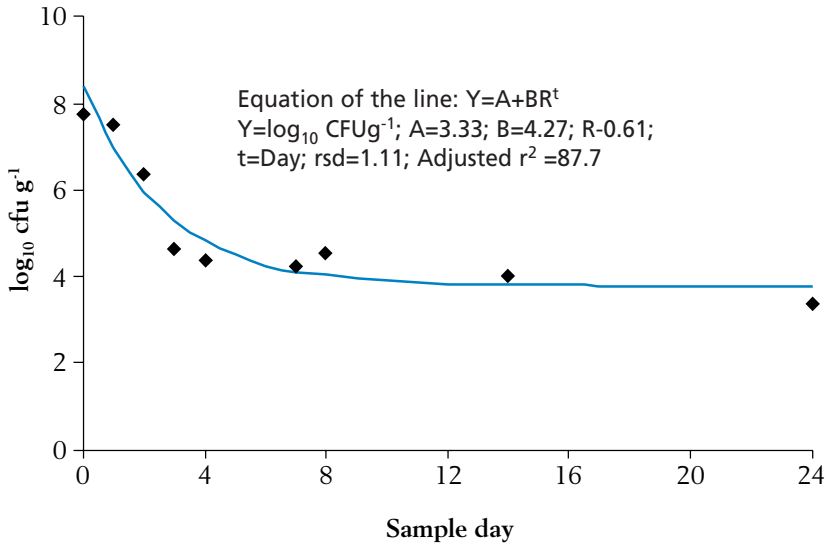


Figure 2: Survival of *E. coli* O157:H7 in faecal clods stored at 15°C for 24 days.

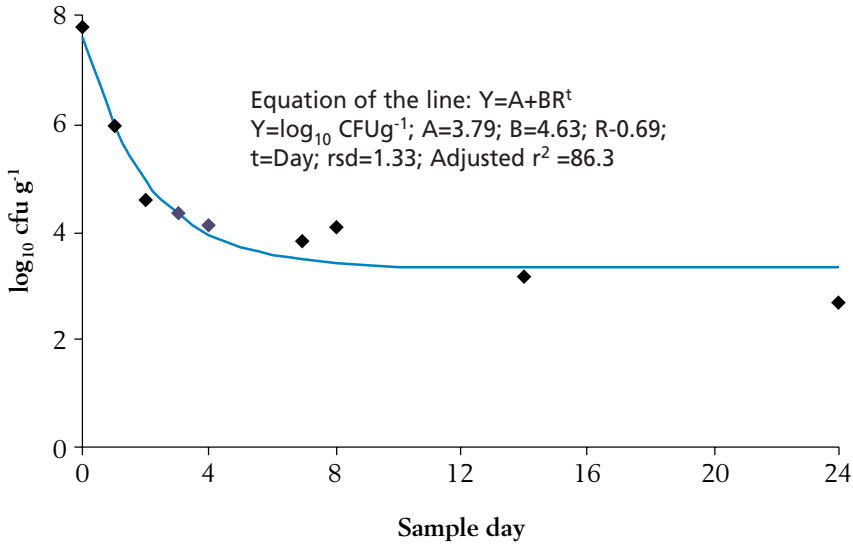


Figure 3: Survival of *E. coli* O157:H7 in faecal clods stored at 4°C for 24 days.

An *E. coli* O157:H7 culture was mixed thoroughly with fresh bovine faeces to give an initial *E. coli* O157:H7 concentration of $\log_{10}$ 7.78 cfu g^{-1}. This material was dispensed into 2 g aliquots and stored at 4 or 15°C in fan assisted incubators resulting in the formation of faecal clods. During storage for 24 days, clods were removed and *E. coli* O157:H7 numbers were enumerated.
E. coli O157:H7 survived in faecal clods stored at 4 and 15°C for up to 24 days (Figures 2 and 3). A rapid decline in numbers was observed during the first 2–3 days of storage with reductions of greater than $\log_{10}$ 3.00 cfu g^{-1}. The rate of decline was less rapid thereafter, indicating the potential of the organism to survive in faecal clods beyond 24 days.
These results show that *E. coli* O157:H7 may be present in faecal clods on the hides of animals presented for slaughter.

CONCLUSIONS

- There is a positive relationship between the level of dirt on the hide and bacterial numbers on the carcass. The relationship is evident at sites on the carcass that are subjected to manual skinning during hide removal.
- The extent of carcass contamination during hide removal can be reduced with increased use of hygiene facilities such as disposable gloves, sterile knives and steels.
- *E. coli* O157:H7 survives well in a desiccated state in faeces and therefore may be present in faecal clods on the hide of animals presented for slaughter.

PART 2: USE OF A TEST BACTERIAL DECONTAMINATION SYSTEM ON BEEF HIDE

Summary

A test decontamination system was used to apply sub-atmospheric steam (steam condensing at temperatures below 100°C) to faecal clods or pieces of beef hide inoculated with *E. coli* O157:H7 in a high liquid content (HLC) and low liquid content (LLC) faecal suspension. The effect of sub-atmospheric steam on the indigenous hide bacterial flora and derived leather quality was also examined. The main results of this work are:

- Steam treatment (80°C for 20 seconds) of faecal clods reduced *E. coli* O157:H7 numbers by more than $\log_{10}$ 3 cfu g^{-1}.
- Steam treatment at 80°C for 20 seconds reduced *E. coli* O157:H7 concentrations on hide by $\log_{10}$ 4.17 cfu g^{-1} (HLC faecal inoculum) and $\log_{10}$ 5.99 cfu g^{-1} (LLC faecal inoculum). The reductions achieved in samples inoculated with LLC faeces were larger than in samples inoculated with HLC faeces.
- Steam treatment at 80°C for 10 seconds resulted in smaller reductions on hide pieces of $\log_{10}$ 1.94 cfu g^{-1} (HLC faecal) and $\log_{10}$ 2.15 cfu g^{-1} (LLC faecal). Reductions were not significantly affected by inoculum type (i.e. HLC faeces or LLC faeces).
- The indigenous bacterial flora on the hide was reduced following treatment with steam at 75 or 80°C for 1, 10 or 20 seconds. However the treatments damaged the hide resulting in a defective leather product following tanning.
- In conclusion, although steam condensing at 75 or 80°C effectively decontaminated beef hide, it may result in an unacceptably damaged product.

INTRODUCTION

During beef carcass dressing, transfer of contamination from the hide surface to the carcass is unavoidable due to the nature of the hide removal process. Contamination can occur by direct contact between the hide and the carcass or by indirect transfer, i.e. from workers' hands, clothes, tools or factory equipment which have had previous contact with the hide. During the life of the animal, the hide becomes contaminated with large numbers of microorganisms derived from a wide range of sources such as faeces, soil, water and vegetation, including pathogens such as *E. coli* O157:H7 and *Salmonella*. Many of these organisms are present on the hide of animals presented for slaughter. Reduction of the bacterial loading on the hide of animals entering the slaughter process would limit the impact and scale of pathogen transfer from the hides to the carcass during the dehiding process.
A test decontamination system using steam at sub-atmospheric pressure (i.e. steam condensing at temperatures below 100°C) was used to reduce *E. coli* O157:H7 numbers in dried faecal clods and in fresh faeces on beef hide. Finally, the effect of the steam treatment on the natural bacterial population on the hide and on subsequent leather quality was examined.

Test decontamination system

Steam has been used to significantly reduce pathogen numbers on beef carcasses (Nutsch *et al.*, 1998; Phebus *et al.*, 1997) and may also have potential as a method to reduce pathogen numbers on the hide. It is an effective heat transfer medium as it gives out large quantities of energy when it condenses. Due to its gaseous nature it can more effectively reach all areas of an irregular shaped object than treatments relying on the spraying of liquids and may inactivate microorganisms *in situ*, making physical removal unnecessary. When produced under vacuum (sub-atmospheric), steam condenses at temperatures below 100°C. This is useful when using steam to treat heat sensitive surfaces such as beef hide. Rapid heating to temperatures below 100°C and rapid cooling following treatment may therefore have the potential to decontaminate hide surfaces without affecting hide quality.
A schematic diagram of the test decontamination system is shown in Figure 4.

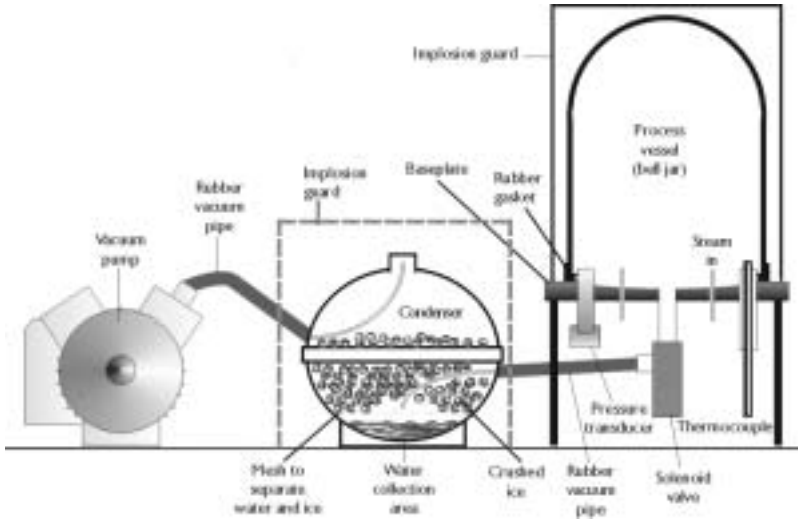


Figure 4: Schematic diagram of the sub-atmospheric steam decontamination apparatus. The hide samples were placed in the bell jar.

It consisted of a process vessel (glass bell jar and stainless steel base plate) within an implosion guard. The chamber could be depressurised using a vacuum pump to provide conditions under which steam condensed at temperatures below 100°C. Steam, produced by an external steam generator (not shown in Figure 4) under atmospheric pressure, could be introduced through the steam inlet valve. The opening and closing of a solenoid valve during treatment enabled the pressure to be maintained between pre-set values. This enabled treatment at the desired temperature for extended periods of time. When the steam treatment was complete, the vessel could be cooled. This was achieved by reducing the pressure, resulting in the evaporation of condensed vapour and the removal of heat.

The effect of steam at 80°C on *E. coli* O157:H7 numbers in faecal clods

Part 1 of this report showed that *E. coli* O157:H7 could survive in faecal clods for at least 24 d. It is imperative therefore, that the hide decontamination

treatment employed would effectively reduce the pathogens numbers in such an environment.

An *E. coli* O157:H7 culture was mixed thoroughly with fresh bovine faeces, to give an initial *E. coli* O157:H7 concentration of approximately 8 $\log_{10}$ cfu g^{-1}. This material was dispensed into 20 g aliquots and stored at 15°C for 72 h in a fan assisted incubator, resulting in the formation of a faecal clod. The faecal clod was treated with steam at 80°C for 20 seconds. *E. coli* O157:H7 numbers in faecal clods were enumerated immediately pre and post treatment.

Steam treatment at 80°C for 20 seconds reduced *E. coli* O157:H7 numbers in faecal clods from $\log_{10}$ 4.20 cfu g^{-1} to below the limit of detection of the assay used ($\log_{10}$ 1.20 cfu g^{-1}) ($P<0.05$) (Figure 5).

These results show that steam treatment at 80°C for 20 seconds may be used to penetrate faecal clods and significantly reduce *E. coli* O157:H7 numbers, thus reducing the potential for cross contamination to occur during slaughter and dressing.

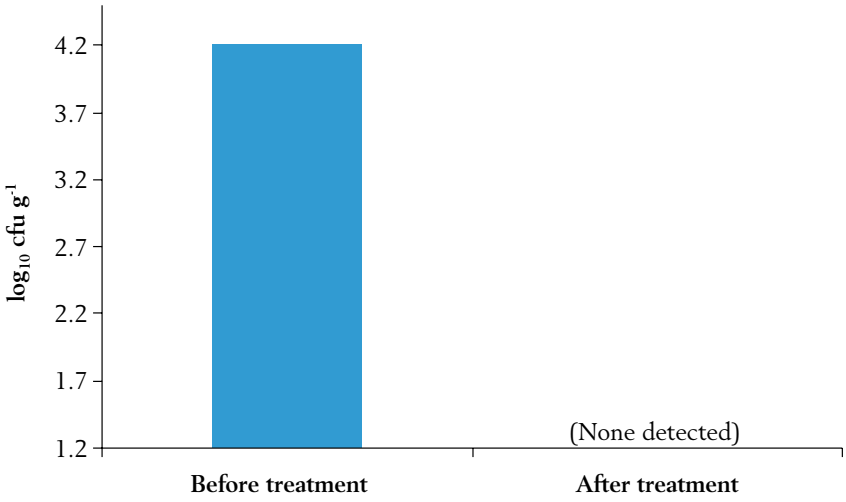


Figure 5: *E. coli* O157:H7 numbers in faecal clods before and after steam treatment at 80°C for 20 seconds.

* Limit of detection of the assay used was $\log_{10}$ 1.20 cfu g^{-1}

The effect of steam at 80°C on *E. coli* O157:H7 numbers on beef hide

Depending on season and animal husbandry practices, faeces of varying consistency may be present on the hide. The objective of this research was to assess *E. coli* O157:H7 reductions in a high liquid content (HLC) and low liquid content (LLC) faecal suspension following treatment with steam at 80°C for 10 or 20 seconds.

E. coli O157:H7 was inoculated onto sections of beef hide (9 x 10 cm) in a HLC and LLC faecal suspension to a concentration of approximately $\log_{10}$ 7 cfu g^{-1}. Inoculated hide pieces were treated with steam at 80°C for 10 or 20 seconds. *E. coli* O157:H7 numbers on hide pieces were enumerated pre and post treatment.

The 20 second treatment resulted in a significantly greater reduction in *E. coli* O157:H7 numbers than the 10 second treatment ($P<0.05$) (Table 4). After 10 seconds, there was no significant difference in reductions between inoculum types (i.e. HLC and LLC faecal suspensions). The 20 second treatment was significantly more effective at reducing *E. coli* O157:H7 numbers on hide pieces inoculated with LLC faeces than those inoculated with HLC faeces ($P<0.05$). These results show that steam treatment at 80°C may be used to significantly reduce *E. coli* O157:H7 numbers present in faeces on the hide. Treatment at

Table 4: The effect of steam treatment of hide at 80°C on *E. coli* O157:H7 reductions.

Treatment time (seconds)	Inoculum type	*E. coli* O157:H7 reductions ($\log_{10}$ cfu g^{-1})
10	High liquid content faeces	1.94[a]
10	Low liquid content faeces	2.15[a]
20	High liquid content faeces	4.17[b]
20	Low liquid content faeces	5.99[c]

Different superscripted letters are significantly different ($P<0.05$).

80°C for 20 seconds is more effective at reducing *E. coli* O157:H7 in low liquid than high liquid suspensions.

The effect of steam at 75 and 80°C on the indigenous bacterial population on the hide and on subsequent leather quality

Hide is an important and economically valuable by-product of the slaughter process. Thus to be commercially useful, hide decontamination procedures should not adversely affect the characteristics of the detached hide or the utility of the derived leather. Beef hide is composed of a corium and grain layer. The corium of the hide provides structure and physical strength to leather. Damage to this layer, particularly from heat, will result in leather that is weak and brittle. The grain layer is external to the corium on the surface of the hide and damage to this largely affects the aesthetic properties of leather. Leather with a damaged or absent grain layer will have a sueded surface. The objective of this research was to examine the effect of steam at different time and temperature combinations on the indigenous hide bacterial population and on subsequent leather quality.

Using the test decontamination system, sections of beef hide (18 x 10 cm) were treated with steam condensing at 75 or 80°C for a duration of 1, 10 or 20 seconds. The indigenous total viable count (TVC) on hide pieces was enumerated pre and post treatment. Steam treated hide pieces and untreated controls were processed in accordance with normal tanning practices and visually inspected and graded by experts in leather production at the United States Department of Agriculture, Agricultural Research Service, PA, USA.

Steam treatment at 75 and 80°C significantly reduced TVCs on hide pieces (Table 5). At each temperature, treatment duration did not significantly affect reductions. Treatment at 80°C for 1 second resulted in similar TVC reductions as treatment at 75°C for 1, 10 and 20 seconds. Treatment at 80°C for 10 seconds resulted in a greater reduction than 75°C for 1 second ($P<0.05$). Treatment at 80°C for 20 seconds resulted in a greater TVC reduction than all 75°C treatments ($P<0.05$).

Visual inspection of leather from all steam treated samples revealed some damage to the outer grain layer causing the underlying corium to become exposed. The exposure of the corium layer results in sueding (Figure 6),

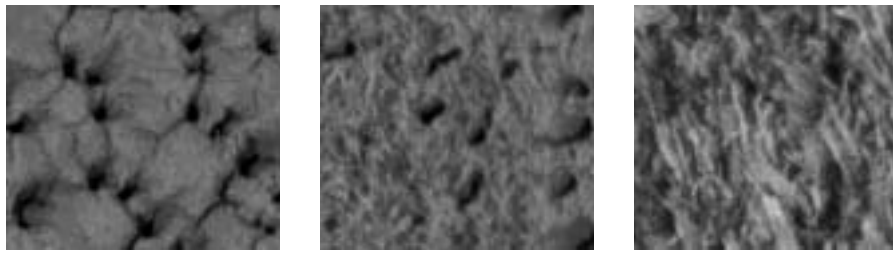
Table 5: The effect of steam treatment of hide at 75 and 80°C on bacterial numbers and leather quality.

Treatment temperature (°C)	Treatment time (seconds)	TVC reduction (log_{10} cfu cm^{-2})	% sueding
	1	1.87[a]	18
75	10	2.51[ab]	83
	20	2.56[ab]	84
	1	2.95[ac]	100
80	10	3.33[bc]	100
	20	3.99[c]	100

Different superscripted letters denote significant differences (P<0.05).

which is an unacceptable leather defect. The extent of sueding on leather derived from hide treated at 75°C ranged from 18 % for the 1 second duration treatment to 84 % for the 20 seconds duration, while all leather derived from hide pieces treated at 80°C was 100 % sueded (Table 5).

These results show that steam treatment at 75 or 80°C for 1, 10 or 20 seconds can result in damage to the hide resulting in an unacceptable product defect following tanning.



No sueding *60 % sueding* *100 % sueding*

Figure 6: The surface of leather magnified 38 times showing no sueding, 60 % sueding and 100 % sueding.

CONCLUSIONS

- A steam treatment at 80°C for 20 seconds, as described in this study, can penetrate into faecal clods reducing *E. coli* O157:H7 numbers by more than $\log_{10}$ 3.0 cfu g^{-1}.
- A steam treatment at 80°C for either 10 or 20 seconds can significantly reduce *E. coli* O157:H7 numbers on beef hide. Treatment time is significant with a greater reduction at the 20 than 10 seconds time interval.
- Significant reductions in the indigenous bacterial flora on the hide can be achieved following treatment at 80°C for 1, 10, or 20 seconds. However, treatment at this temperature results in damage to the hide, which causes sueding on 100 % of leather surfaces following tanning. Significant reductions can also be achieved following treatment at 75°C for 1, 10 or 20 seconds. Treatment at 75°C results in significantly less damage to the hide and consequently, there is less sueding on the surface of the resulting leather, especially following the 1 second treatment.
- Although steam condensing at temperatures at or below 80°C reduced bacterial numbers, the treatment damaged the hide resulting in leather with an unacceptable defect. If similar damage occurred on a commercial scale, steam treatment of beef hide under the conditions reported in the present study would not be a viable option.

RECOMMENDATIONS

Hide removal

Removal of hides should be carried out in a manner that avoids a] contact between the hide and the carcass and b] contact between the carcass and workers' hands, tools or equipment, which had previously contacted the hide. Knives and steels used in the dehiding operation should be sterilised in water at 82°C.

Evisceration

Rodding and bung tying must be carried out on all animals to prevent transfer of gut contents to the carcass during evisceration.

Decontamination Measures

Cold (10-15°C) and warm (15-40°C) potable water washes will not reduce the incidence of contamination on carcasses and may spread contamination to carcass areas not previously affected.

A hot (75-95°C) water wash will reduce bacterial contamination on carcasses (Barkate *et al.*, 1997; Castillo *et al.* 1998).

Steam pasteurisation will also reduce bacterial contamination on carcasses (Nutsch *et al.*, 1998; Phebus *et al.*, 1997). Damage to the carcass surface during this process is limited by immediate chilling with water.

Steam vacuuming (Dorsa *et al.*, 1997; Kochevar *et al.*, 1997) is a relatively new technology used to remove concentrated spots of visible contamination of less than 2.5 cm (1 inch) in diameter, from the surface of carcasses. It may also be used to reduce bacterial numbers at carcass sites where contamination may not necessarily be visible, though high bacterial numbers might be expected. Steam vacuuming operates by removing visible contamination such as faeces, hair and ingesta under vacuum while simultaneously reducing bacterial numbers on the carcass surface using hot water (above 82°C).

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PUBLICATIONS FROM THIS PROJECT

Scientific

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