



# Microbiological assessment of through-wool trotter removal of ovine carcasses

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Ministry of Agriculture and Forestry  
PO Box 2526  
Pastoral House, 25 The Terrace  
Wellington 6140  
[www.maf.govt.nz](http://www.maf.govt.nz)

Telephone: 0800 008 333

Facsimile: +64 4 894 0300

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## Microbiological assessment of through-wool trotter removal of ovine carcasses

The production of sheep and lamb meat is a significant part of the economy of New Zealand. Technological advances, such as inverted dressing, over many years have enhanced the efficiency, productivity and hygiene of sheep meat production. Contact between the fleece and the carcass is recognised as one of the most serious sources of microbial contamination occurring during the slaughter and dressing of sheep. In hygienic dressing procedures, such contamination is minimized by avoiding cutting through the pelt or by cutting from the inside to the outside in primary opening cuts.

While contamination during trotter removal has traditionally been avoided by skinning the legs before they are cut, regulations for dressing of lambs and sheep do allow the removal of trotters by cutting through wool. However, a second cut must be made after de-pelting to remove the "contaminated" cut through wool surface of the hock stub, imposing additional dressing costs on the meat industry. Cost savings could be made, however, if the level of contamination on carcass meat from through wool cutting during trotter removal does not add significantly to overall carcass contamination and the second cut is not required.

Unfortunately, this study shows that trotter removal by cutting through wool without subsequent trimming of the hock stub will compromise the hygienic status of lamb carcasses.

Mechanical cutters became 100-fold more contaminated on contact with wool, and hock stubs from carcasses where trotters were removed mechanically through wool had increased visible contamination, even after trimming, with up to 25 strands of wool (~40 %) and small fragments of bone (~10%).

Microbiological contamination at or adjacent to the cut point was greater when the trotters were removed mechanically through wool, although contamination was localized to the hock stub. The hock stubs from long-wooled, dirty lambs were generally more contaminated (0.5 log<sub>10</sub> count), albeit not statistically significant.

Hock stubs removed mechanically through wool contribute at least 23% of the overall carcass contamination from opening cuts on the legs and flap, and a greater proportion (~50%) on the high value vacuum-packaged chilled hind-leg and shank cuts.

It is concluded that the level of visible and microbial contamination on carcass meat is greatest when mechanically removing trotters by cutting directly through wool. The quality (e.g. visible contamination and storage life) and food safety consequences of these observations are unknown but should be considered for chilled products, especially where or when long-wooled dirty animals are more frequently processed. Mitigation requires additional procedures such as removal in the cutting room of a further length of the hock stub from the fully dressed carcass, or similar decontamination procedure.

Updated 5 April 2011





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# 1 Introduction

## 1.1 Background

The production of sheep and lamb meat is a significant part of the economy of New Zealand. Technological advances over many years have enhanced the efficiency, productivity and hygiene of sheep meat production, none more so than the introduction of inverted dressing (Longdell, 1992) where the de-pelting operation starts at the cleaner end of the carcass, and the pelt is moved downwards towards the rear, more contaminated, end.

Contact between the fleece and the carcass is recognised as one of the most serious sources of microbial contamination occurring during the slaughter and dressing of sheep. In hygienic slaughter and dressing procedures contact between fleece and carcass is minimized. An area of special concern is the transfer of microorganisms to the carcass surface by dressing implements that cut through the hide from the outside to the inside. In hygienic dressing procedures, this type of transfer is minimized if such knife cuts are made as spear cuts with subsequent cuts made by cutting from the inside to the outside.

For the removal of trotters, cutting through wool is avoided if trotters are skinned before they are cut. Should trotters be removed by means of a "through wool" cut then a second cut, after pelt removal, must be made to remove the "contaminated" cut through wool surface of the shank stub. A reason for the imposition of such regulations is that they were considered necessary to assist in the production of hygienically acceptable carcasses. However, such regulations impose additional dressing costs on the meat industry.

The conduct of this study was to provide the scientific data necessary to substantiate or abrogate the contention that trotter removal with cutting through wool compromises the hygienic status of ovine carcasses.

Risk management question to be answered;

- Is the level of contamination on carcass meat from through wool cutting during trotter removal greater than that deposited during traditional trotter removal procedures?
- Does the level of contamination on carcass meat from through wool cutting during trotter removal add significantly to overall carcass contamination?

## 2 New Zealand Regulations

### 2.1 IS/IAS 5: Slaughter and Dressing

The following highlights relevant sections in Industry Standard 5 (IS5): Slaughter and Dressing (2002) pertaining to trotter removal;

#### 24.2.1 Use of automatic trotter removers.

24.2.2 Automatic trotter removers shall be rinsed after each carcass unless the trotter is removed distally to the joint and the stub is subsequently shortened.

24.2.3 If for any reason the shears are grossly contaminated they shall be washed and sterilised between trotters.

24.2.4 The area where the trotter is cut off shall be exposed:

- either by complete skinning of the joint
- or by the removal of a strip of skin from the surface of the trotter facing the shears operator. The strip shall start above the joint and widen as it extends down the trotter. The strip shall be wide enough to allow the skin to move freely over the joint. The remaining skin shall be gathered to the rear of the trotter as it is held for removal.

24.2.5 The removal of the trotter by cutting through wool and skin distally to the joint and subsequent shortening of the stub after completion of pelting is also acceptable.

#### 24.2.6 Manual trotter removal

The standard for the removal of hocks by knife remains unchanged ie cutting through pelt and wool is not permitted unless it occurs after the joint is severed. If the pelt is cut in this manner the knife shall be rinsed between trotters.

## 2.2 Meat Code of Practice - Slaughter and Dressing (proposed)

The following highlights the relevant sections of the proposed Meat Code of Practice - Slaughter and Dressing pertaining to ovine trotter removal. These sections are intended to replace sections 24.2.1 to 24.2.6 above;

### 24.2 Trotter removal

24.2.1 Trotters may be removed by incision directly through the skin and joint. Good operating practice can be improved with this process if the trotter stub is subsequently removed.

24.2.2 If for any reason the shears are grossly contaminated they shall be washed and sterilised between trotters.



## 3 Hygiene Assessment Methods

### 3.1 Trotter removal procedures

The New Zealand standard trotter removal and three alternative procedures using mechanical cutters with and without pre-skinning of the pelt were implemented at a New Zealand export ovine processing facility with a single inverted ovine dressing chain.

#### 3.1.1 Pelt removal procedures

Prior to pelting in an inverted ovine dressing chain, the carcass was suspended by all four legs with each pair of legs spread apart to facilitate opening of the pelt on the inside of the legs. Initial opening began on the foreleg with an opening spear cut from the neck up each inside leg, flay of the skin away from the knuckle (fore-hock) and finally separation of the skin from the legs distal to the carpal joint. The shoulders were then manually cleared and the ventral spear cut and anal ringing procedures carried out.

Skinning of the hind legs involved an initial ring cut around the trotters distal to the tarsal joint followed by a spear cut down the inside of each leg (hock) to the inguinal ring (cod cut). The hind legs were then dropped from the spreaders (four variants) and the pelt mechanically removed. The whole hind trotter was removed subsequent to pelt removal (traditional process) or during the dropping process. Where the trotter was removed by cutting through wool, a further length of hock stub was removed following depelting prior to evisceration,

The hind legs were then re-hung with gambrels and the forelegs dropped; the fore-trotters removed either by knife or mechanical cutter through the carpal joint.

Other than the two through wool mechanical cutting procedures, slaughter and dressing was carried out as per normal operation (e.g. manning levels, chain speeds etc) and in compliance with New Zealand regulatory requirements.

The forequarters of carcasses were washed prior to evisceration to comply with European Union (EU) export requirements at the time. The whole carcass, including the hind legs, was not washed.

#### 3.1.2 Alternative hind trotter removal procedures

The hind legs were dropped and trotters removed using four alternative procedures:

- (a) The opened hind legs were dropped intact from the spreaders, the hide mechanically removed, and the trotter removed by cutting through the skinned tarsal joint with a knife.
- (b) The hind legs were fully cleared on the spreaders and then dropped by mechanically cutting through the skinned tarsal joint prior to mechanical hide removal.
- (c) The hind legs were dropped by mechanically cutting through the distal leg at the initial ring cut; the skin having shrunk back about 1cm from the cut line (partially skinned). The hide was then mechanically removed, and the skinned hock subsequently shortened by cutting through the tarsal joint with a second mechanical cutter.
- (d) The hind legs were dropped by mechanically cutting through the uncleared leg distal to the tarsal joint. The hide was then mechanically removed, and the skinned hock subsequently shortened by cutting through the tarsal joint with a second mechanical cutter.

## 3.2 Animals

Evaluation of the trotter removal procedures was carried out solely on lambs due to resourcing limitations during ewe processing.

Mobs of animals to be processed, and animals to be processed by each procedure were selected randomly from the chain. Specific selection criteria were not applied. Neither mobs nor animals were selected based on colour, length and cleanliness of wool (Biss *et al*, 1995). However, mob characteristics were recorded and representation in each procedural group recorded.

## 3.3 Visible contamination

Visual inspection for visible contaminants was conducted on the slaughter chain prior to the pre-evisceration wash and again on the cooling floor following completion of carcass processing.

For each of the trotter removal procedures, the right rear hock stubs of approximately 600 carcasses were evaluated for the presence of visible defects and contamination based on the criteria detailed in the MAF Qual defect classification chart for ovine carcasses<sup>1</sup>.

Contaminants included the presence of wool and bone fragments, as defined below, grease, ingesta and black hair. Rare contamination with skin and extraneous contaminants were recorded.

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<sup>1</sup> MAF Quality Management (1987) Post-Mortem Inspection Programmes: Process control system for contamination and specified defects on ovine carcasses. Draft - Project 19: Ref I5IIII/19: June 1987

- Wool: No defect (<5 strands), m<sup>-</sup> (5-25 strands), m<sup>+</sup> (26-50 strands), M (>50 strands), C (gross)
- Bone: Given that the the diameter of the bone at the shank is between 20 and 30 mm, any unattached bone chips (generally <10mm) were considered contamination.

Carcasses without defects on the slaughter floor were not reassessed on the cooling floor. The percentage of “defect free” carcasses described for the cooling floor was therefore the sum of those without defects on the slaughter floor and those declared defect free on the cooling floor after any subsequent processing. Recall that the hindquarters of the carcasses are not washed.

Notwithstanding the above, five (5) defect-free carcasses per day were re-assessed on the cooling floor as a quality check for slaughter-floor visual assessment.

### 3.4 Microbiological assessment

The hygienic status of the wool, processing equipment and carcasses, and any association between each, was evaluated, where appropriate, for four hind trotter removal procedures.

The microbiological status of the cut surface of hock stubs was determined from microbiological analyses performed on the exposed articular surface of severed trotters. This approach was applied to sampling immediately after trotter removal and at the end of carcass processing (on entry to the cooling floor) but in the latter case samples were taken from the exposed hock stub articular surface that remained attached to the carcass.

The microbial bioload carried on the trotter cutter blade, knife or mechanical shear, was determined before and after trotter removal, and any association between the microbial bioload on the equipment and contamination of the cut surface determined.

The bioload carried by wool on the trotters was determined in the case of mechanical cutters applied to unskinned and partially skinned trotters, and any association between the microbial bioload on the wool and cutting equipment determined.

The microbiological profile of cut hock surfaces obtained using the four trotter removal procedures were compared not only with each other but also relative to overall carcass contamination to determine if the hygienic status of ovine carcasses is compromised when trotters are removed by a "cut through wool" technique.

### 3.4.1 Sampling procedures

Historically, microbiological sampling from carcasses can provide standard deviations in the range of 0.3 to 1.0 log<sub>10</sub> cfu/unit. Therefore, in order to draw statistically reliable conclusions from sample groups with an expected difference of 0.5 log<sub>10</sub> units, expected standard deviation no greater than 1.0 log<sub>10</sub> units, desired power of 0.8 and alpha of 0.01, 50 samples were taken for each treatment (SigmaStat 2.03, SPSS Inc., USA).

Fewer samples were collected for examination of cutting blades, hock stubs and whole carcasses at the end of processing as testing was only intended to either indicate trends or identify areas where additional sampling would be required.

Trotter and hock stubs: With each trotter removal procedure, 50 severed trotters were collected for microbiological sampling immediately after their removal from the carcass. The exposed articular surface was swab sampled using a moist, then a dry, cotton tipped swab. In the case of those procedures that cut through wool, care was taken to prevent post cutting contamination of the exposed articular surface as a result of contact with wool remaining on the trotter.

After completion of carcass processing, the exposed articular surfaces of 20 hock stubs attached to the carcass were swab sampled for each of the four trotter removal procedures. All swab samples were placed in an insulated container with ice pending transfer to the laboratory. At the laboratory, swabs were suspended in 10ml of MRD, and serially diluted for quantitative analysis.

The area of trotter and hock articular surface sampled was determined by delineating the edge of the stub with ink and transferring an impression to graph paper. The outline was excised and the proportionate area (cm<sup>2</sup>) determined by weighing. The average of 50 stubs measured was 5.7cm<sup>2</sup> with a standard deviation of 1.06 cm<sup>2</sup>.

Trotters: In addition to sampling the trotter stubs (described above), the skinned trotters of 20 carcasses were swab sampled immediately after removal from a location 20mm from the cut end and on the opening cut line. A five (5) cm<sup>2</sup> area of each site delineated by a metal template was sampled using a moist, then a dry, cotton tipped swab.

All swab samples were placed in an insulated container with ice pending transfer to the laboratory. At the laboratory, swabs were suspended in 10ml of MRD, and serially diluted for quantitative analysis.

Cutting blades: Cutting blades were sampled using a folded 10 cm x 10 cm sterile cotton gauze swab. A sterile Whirl bag was aseptically inverted over the sampler's right hand and then used to pick up a dry sterile swab. Five ml of Maximum Recovery Diluent (MRD, Difco, USA) was poured onto the swab immediate before the knife or cutter blade was swabbed.

After swabbing, the Whirl bag was inverted over the swab, closed and placed with the swab inside on ice pending transfer to the laboratory. At the laboratory, swabs from the cutter blades were suspended in a further 35ml of MRD (40ml total), and serially diluted for quantitative analysis.

The area of cutter surface sampled was determined by tracing the edge of the cutter onto graph paper. The outline was excised and the proportionate area (cm<sup>2</sup>) determined by weighing. The area sampled on the mechanical cutter was 128 cm<sup>2</sup>. The surface area sampled of the knife used for cutting through the skinned hock ranged from 40-49 cm<sup>2</sup>; the predominant knife having an area of 44 cm<sup>2</sup>.

Wool: Twenty (20) trotters removed by each procedure (mechanical cutting through unskinned and partially skinned hocks) were placed into individual plastic bags immediately after microbiological sampling of the exposed articular surface, and placed in insulated containers with ice pending transfer to the laboratory.

For each trotter, five (5) g of hock wool was clipped from the end nearest the cut end, placed into a sterile plastic bag, washed with 45ml of MRD, and serially diluted for quantitative analysis.

Carcasses after processing: In addition to sampling the hock stubs (described above), the hock, leg and brisket of 20 carcasses were sampled immediately following post-mortem inspection. A five (5) cm<sup>2</sup> area of each site delineated by a metal template was sampled using a moist, then a dry, cotton tipped swab.

- The hock site was located 50mm proximal to the hock stub.
- The hind leg site was defined as a area on the outside of the leg 1/3 up on a vertical line originating at the midpoint of a line between the ischial crest and stifle, and extending to a line horizontal to the cut end of the hock. This site is not directly contaminated during dressing on an inverted chain.
- The lower edge of the brisket sample site was an imaginary line drawn straight across (medially) from the midline cut at the height of the elbow of the carcass.

All swab samples were placed in an insulated container with ice pending transfer to the laboratory. At the laboratory, swabs were suspended in 10ml of MRD, and serially diluted for quantitative analysis.

### 3.4.2 Microbiological analysis

All samples were quantitatively analysed for aerobic plate count (APC). Appropriate dilutions were spread onto plate count agar (Difco, USA) and incubated at 30°C for 72 hours. Counts were recorded as log<sub>10</sub> colony forming units (CFU) /cm<sup>2</sup> or /g.

### 3.4.3 Relative contamination

The extent of carcass contamination by through wool processing (standard opening cut lines, head removal and trotter removal) was calculated by measuring the length of opening cut lines and the circumference of the trotters and neck, and assuming a 1cm wide area of direct contamination either side of the cut line (i.e. area contaminated = 2 [cm] x circumference [cm] + area of exposed end surface [cm<sup>2</sup>]). Neck and shank measurements were collected at two premises and reflected the range of ovine carcass sizes processed.

The length of the foreleg opening Y-cut, hind-leg opening cut and opening belly cut were determined from a previous MAF-NZFSA project (LeRoux *et al*, 2004). Microbiological profiles for the foreleg opening Y-cut and opening belly cut were obtained from the national profiles (1997-2006, n=61,132) of the New Zealand MAF/meat industry *National Microbiological Database* microbiological monitoring programme<sup>2</sup>.

### 3.4.4 Statistical analysis

All statistical analyses (T-test, Chi square test and Mann-Whitney rank sum test) were carried out using SigmaStat 2.03, SPSS Inc., USA.

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<sup>2</sup> <http://www.foodsafety.govt.nz/industry/general/nmd/>

## 4 Results and Discussion

### 4.1 Animal presentation

Mobs of animals to be processed, and animals to be processed were not specifically selected based on colour, length and cleanliness of wool. However, mob characteristics were recorded and representation in each procedural group recorded.

Few black-wooled sheep were presented for slaughter during the trial, but were not specifically excluded from the trial groups. The results are therefore representative of a predominantly white-wooled population.

Wool length was short in 42% of animals and medium/long in 58%. Wool was clean in 43% of animals, moderately dirty in 38% and dirty in 19% (overall dirty 57%). Furthermore, the mix of length and cleanliness of wool was generally similar for each procedural group (Table 1), and is considered not to add bias to the visible and microbial contamination results obtained.

Table 1 Relative wool length and cleanliness for animals processed using the four alternative trotter removal procedures (%)

Hair length, cleanliness	Knife, skinned trotters	Mechanical, skinned trotters	Mechanical, part skinned trotters	Mechanical, through wool
Short, clean	40%	30%	30%	31%
Short, dirty	10%	10%	8%	10%
Med/long, clean	10%	2%	10%	10%
Med/long, mod dirty	30%	48%	32%	31%
Med/long hair, dirty	10%	10%	20%	18%

### 4.2 Visible contamination

Visual inspection for visible contaminants on the right hock stub of carcasses was carried out on the slaughter chain prior to the pre-evisceration wash and again on the cooling floor following completion of carcass processing. The results are presented in Table 2.

Table 2 Visible contamination of hock stubs following alternative trotter removal procedures. Percentage (%) of carcasses contaminated prior to (slaughter floor) and following the pre-evisceration wash (cooling floor).

	Knife, skinned (n=600)		Mechanical, skinned (n=642)		Mechanical, partly skinned (n=604)		Mechanical, through wool (n=656)	
	Slaughter floor	Cooling floor	Slaughter floor	Cooling floor	Slaughter floor	Cooling floor	Slaughter floor	Cooling floor
Defect free <sup>*</sup>	91.7%	98.0%	58.3%	81.0%	20.9%	48.3%	23.8%	57.0%
Wool <sup>**</sup> m <sup>-</sup>	1.7%	0.3%	1.6%	0.6%	49.0%	37.7%	53.4%	30.2%
m <sup>+</sup>	-	-	-	0.3%	6.3%	2.2%	4.9%	6.1%
M	-	-	0.3%	0.2%	1.7%	0.3%	2.4%	0.9%
C	-	-	0.3%	0.3%	0.7%	-	2.7%	-
Bone fragments	4.3%	1.7%	39.9%	17.4%	33.4%	11.6%	21.0%	5.5%
Grease	2.0%	-	0.3%	-	6.3%	-	8.5% <sup>***</sup>	0.9%
Ingesta	-	-	-	-	2.3%	0.3%	4.0% <sup>***</sup>	0.9%
Black hair	-	-	-	-	2.3%	1.0%	0.6%	-

\* Carcasses without defects on the slaughter floor were not reassessed on the cooling floor. The percentage of "defect free" carcasses described for the cooling floor is the sum of those without defects on the slaughter floor and those declared defect free on the cooling floor after the pre-evisceration wash and subsequent processing.

\*\* Key to wool contamination grades: No defect (<5 strands), m<sup>-</sup> (5-25 strands), m<sup>+</sup> (26-50 strands), M (>50 strands), C (gross)

\*\*\* Visible contamination at this rate is not typical of current New Zealand processing under HACCP-based risk management programmes.

Note: Percentages don't necessarily sum to 100% because multiple defects were observed on individual carcasses.



A proportion of carcasses that had been declared visibly defect free on the slaughter floor were re-assessed on the cooling floor. All carcasses processed manually on a fully skinned hock that were defect free on the slaughter floor remained defect free on the cooling floor, as expected. The percentage of hock stubs contaminated with bone fragments on carcasses processed using mechanical cutters did not increase. Similarly, the percentage of hock stubs contaminated with wool on carcasses processed using mechanical cutters directly through the wool did not increase.

Ingesta and black wool were not detected on the stubs of fully skinned carcasses but were detected on up to 4% of partially skinned or unskinned carcasses prior to mechanical removal of the trotter. While, trimming procedures were effective reducing ingesta and black wool contamination to <1%, ingesta contamination at this rate is not considered typical of current processing under HACCP-based risk management programmes<sup>3</sup>.

Grease was detected on hock stubs from all groups, although the reason for presence of grease on manually cut stubs remains unknown. The negligible presence on stubs from fully skinned but mechanically cut trotters (0.39%) and greater prevalence 6-8% using mechanical cutters through partially skinned or unskinned wool suggests that the grease is not from the mechanical cutters. However, notwithstanding the up to 8% prevalence on the slaughter floor, trimming procedures removed the vast majority of grease from the carcasses of all procedural groups prior to leaving the slaughter floor. Again, contamination at this rate is not considered typical of current processing under HACCP-based risk management programmes.

Skin and other extraneous contaminants were rarely observed.

Visible wool contamination after trotter removal was minimal with trotters manually or mechanically removed through a fully skinned hock (Table 2). Residual wool contamination (0-0.6%) was observed following trimming when contamination was initially low.

A substantially greater degree of wool contamination of the hock stubs (1.6% up to 49-53%) was observed with mechanical cutting through both partially skinned and unskinned hocks especially in the lower grades  $m^-$  and  $m^+$ , and this contamination was only partially removed by the time the carcasses reached the cooling floor (as expected without a carcass wash). Residual wool remained at  $m^-$  (38% and 30%),  $m^+$  (2.2% and 6.1%) and M (0.3% and 0.9%) respectively on partially skinned and unskinned stubs.

Stubs from all groups were contaminated with bone fragments after trotter removal but those of the three mechanically cut trotters at 5-10 times the prevalence (Table 2). Trimming procedures

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<sup>3</sup> This study was carried out in August 1993.

lowered the prevalence of bone fragments by 64% (fully and partially skinned groups, respectively) and 72% (unskinned).

The predominant visible contaminants remaining on the hock stubs after trotter removal are strands of wool up to 50 in number, and bone fragments likely very small in size. Trimming procedures were not fully effective in removing this visible contamination and it is therefore likely that up to ~40 % of hock stubs will remain contaminated with up to 25 strands of wool and up to ~10% contaminated with small fragments of bone. The quality and food safety consequences of these observations are unknown but elimination would require additional procedures such as removal of a further length of the hock stub from the fully dressed carcass or a full carcass wash, keeping in mind, however, that wash water from the hock stub will run down over the carcass potentially contaminating previously uncontaminated parts of the carcass.

### 4.3 Microbiological assessment

#### 4.3.1 Contamination of cutting equipment

Microbiological contamination of cutting equipment was evaluated prior to and after cutting through wool.

The mean APC of wool from 20 trotters was 8.80 log<sub>10</sub> cfu/g (Table 3)

Blades that had been commercially sterilised and did not contact wool remained contaminated in the range of 2.28-2.53 log<sub>10</sub> CFU/cm<sup>2</sup> (Table 3). In contrast, the mechanical cutters became 100-fold more contaminated (2 log<sub>10</sub> count increase) on contact with the wool.

This high level of contamination was likely transferred to the trotter stubs and adjacent carcass meat during trotter removal (Table 4).

#### 4.3.2 Contamination of carcass surfaces

Microbiological contamination of carcass sites following the four alternative trotter removal procedures is presented in Table 4.

In general, microbiological contamination (APC) on the trotter and hock stubs and on the trotters and hocks adjacent to the location of the cut was greater ( $p < 0.05$ ) when the trotters were removed mechanically through partially skinned or unskinned hocks (mean 2.87-4.08 log<sub>10</sub> cfu/cm<sup>2</sup>) than when the hock was fully skinned prior to manual or mechanical cutting (mean 2.28-2.76 log<sub>10</sub> cfu/cm<sup>2</sup>).

Table 3 Microbiological contamination of wool and cutting equipment before and after alternative trotter removal procedures. Aerobic plate count,  $\log_{10}$  CFU/cm<sup>2</sup> (std. dev.) and  $\log_{10}$  CFU/g (std. dev.)

Group	Blades before		Wool		Blades after	
	n	Mean/cfu <sup>2</sup>	n	Mean/g	n	Mean/cfu <sup>2</sup>
Knife, through skinned hock	10	2.30 (0.91)			11	2.53 (0.60) ac
Mechanical, through skinned hock	19	2.28 (0.55)			11	2.49 (0.61) bd
Mechanical through partially skinned hock	10	2.33 (0.99) f	10	8.63 (0.38)	10	4.39 (0.50) cdf
Mechanical, through wool	11	2.60 (0.92) e	10	8.56 (0.21)	11	4.51 (0.39) abe

a, b, etc – Statistically different pairings at  $p < 0.05$  (Mann-Whitney U test for non-parametric data)

This higher level of contamination was likely transferred to the hock stubs and adjacent carcass meat from the cutters during trotter removal (Table 3).

The difference in the APC (mean  $\log_{10}$  cfu/cm<sup>2</sup>) between the manual/skinned procedure and mechanical unskinned procedure for the pre-wash trotter stubs and trotters (1.59 and 1.31, respectively) and after completion of processing, the hock stubs (1.57), is substantial and statistically significant, while that on the hock itself after completion of processing was insignificant (0.29).

Partial skinning of the hock prior to mechanical cutting made less than mean 0.5  $\log_{10}$  cfu/cm<sup>2</sup> difference, albeit statistically significant, on the trotter stubs and that difference disappeared on completion of processing (difference of mean 0.17  $\log_{10}$  cfu/cm<sup>2</sup>).

The level of contamination on the cut surface of the trotter (pre-wash) and hock stub (post processing) did not differ although the mean count on the hocks of fully dressed carcasses that had been processed using mechanical cutting through wool dropped by one (1)  $\log_{10}$  cfu/cm<sup>2</sup> ( $p < 0.01$ ). This final count was no greater than that observed for the other procedure groups at the completion of processing.



Table 4 Microbiological contamination of carcass sites following alternative trotter removal procedures. Aerobic plate count,  $\log_{10}$  CFU/cm<sup>2</sup> (std. dev.)

Group	Trotter stubs		Trotters		Hock stubs		Hock		Leg		Brisket	
	N	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean
Knife, through skinned hock	50	2.41 (0.85) bd	20	2.62 (0.96) ac	20	2.28 (0.59) ac	20	2.76 (0.86)	20	2.85 (0.77)	20	3.32 (0.65)
Mechanical, through skinned hock	49	2.49 (0.63) ce	19	2.59 (0.66) bd	19	2.42 (0.62) bd	20	2.58 (0.73) b	20	2.91 (0.48)	20	3.60 (0.62)
Mechanical through partially skinned hock	50	3.70 (0.64) ade	20	3.57 (0.72) cd	20	3.82 (0.66) cd	20	3.26 (0.93) ab	20	2.81 (0.43)	20	3.59 (0.59)
Mechanical, through wool	50	4.08 (0.52) abc	20	3.90 (0.45) ab	20	3.99 (0.32) ab	20	2.87 (0.53) a	20	2.71 (0.49)	19	3.29 (0.76)

a, b, etc – Statistically different pairings at  $p < 0.05$  (Mann-Whitney U test for non-parametric data)

### 4.3.3 Effect of stock presentation

While procedure groups were not controlled for stock presentation (hair length and cleanliness), animals were retrospectively sorted and the effect of stock presentation on microbial contamination of the trotter stubs during removal evaluated (Table 5).

Again, generally, mechanical cutting through partially skinned or unskinned hocks resulted in more contamination on the trotter stubs.

The level of contamination on the trotter stubs of animals with long dirty wool was on average nearly  $0.5 \log_{10} \text{ cfu/cm}^2$  higher than that from medium/dirty, medium/clean and short/clean animals, for both partially skinned and unskinned groups.

This difference was, however, not statistically significant.

Nevertheless, considering that this trial was carried out in the North Island where animals tend to be cleaner, and was limited to a short trial period (weather unknown), the effect of cutting through the wool in geographic areas where stock are generally woollier, dirtier and break feeding is utilised, e.g. Southland, needs to be considered during implementation by meat processors.

### 4.3.4 Proportionality of contamination

Currently, contamination is introduced from the pelt onto the underlying meat under inverted dressing systems during the anal scallop cut and opening cut on the hind legs; during neck incision and head removal; during opening of the skin on the forelegs (Y-cut); and during rip-down (ventral belly cut), and to a lesser extent flanking. It is important, therefore, to define the relative contribution of contamination at the hock stubs to the overall microbial contamination introduced to the carcass during dressing.

The preceding sections have indicated that by the end of processing, the hock stubs of carcasses where trotters have been removed mechanically directly through wool remain approximately  $1.7 \log_{10} \text{ cfu/cm}^2$  more contaminated than those that are manually removed after skinning the hock ( $3.99$  vs  $2.28 \log_{10} \text{ cfu/cm}^2$ ). Arithmetically speaking, there are still 50 times the number of bacteria per  $\text{cm}^2$  than when using the manual, skinned procedure.

However, it is important to consider that while this difference on the hock stub is real, it is localized. The mean count on the hock itself within 20mm of the cut is only  $0.11 \log_{10}$  counts greater than that of the manual procedure ( $2.87$  vs  $2.76 \log_{10} \text{ cfu/cm}^2$ ); in reality, not different at all.

Table 5 Microbiological contamination of trotter stubs relative to wool length and cleanliness following alternative trotter removal procedures. Aerobic plate count,  $\log_{10}$  CFU/cm<sup>2</sup> (std. dev.)

Group	Short hair				Medium hair				Long hair			
	Clean/slightly dirty		Moderate/very dirty		Clean/slightly dirty		Moderate/very dirty		Clean/slightly dirty		Moderate/very dirty	
	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean
Knife, through skinned hock	10	2.30 (0.88) b d f x o π Ë Ъ ж	-	-	5	3.25 (1.01) a b h ε ρ κ φ	15	2.16 (0.77) a j l r y ζ Æ ë	1	-	10	2.61 (0.70) n p s z ζ Æ Ë @
Mechanical, through skinned hock	20	2.17 (0.54) e g a η σ f Ÿ ε φ @ \$ &	-	-	5	2.55 (0.68) l t θ я ε υ ю	15	2.81 (0.70) k m u β ψ ч л \$	-	-	9	2.65 (0.31) o q v γ λ Ъ ш ë &
Mechanical through partially skinned hock	19	3.56 (0.63) c f g w ч	2	-	1	-	10	3.59 (0.80) l m ξ Ë Æ Γ ε Ъ	5	3.85 (0.63) Ъ Æ Ë Ÿ u ч ш	13	3.92 (0.53) p q ж к э ю л
Mechanical, through wool	24	4.01 (0.50) c d e r s t u v	-	-	16	4.08 (0.46) h l w x y z α β γ	5	4.04 (0.42) j k σ ε ζ η θ λ	-	-	5	4.48 (0.87) п о ч ф п р с я ψ

a, Ъ, etc – Statistically different pairings at  $p < 0.05$  (Mann-Whitney U test for non-parametric data)  
 Hair length versus cleanliness within a procedure: Only (a)  
 Cleanliness versus hair length within a procedure: Only (b)  
 Hair length and cleanliness between procedures, with respect to hair length: (c-q)  
 Hair length and cleanliness between procedures, all permutations: (r-&)

Furthermore, this count is no different than that on the outside hind leg site (Table 3) that has not been subject to any direct wool contamination event (2.87 vs 2.71 log<sub>10</sub> cfu/cm<sup>2</sup>), and is 0.4 log<sub>10</sub> counts less than the count on the brisket (2.87 vs 3.29 log<sub>10</sub> cfu/cm<sup>2</sup>); a count arising from the rip-down procedures and considerable contact during evisceration.

In order to further demonstrate the localized and therefore insignificant, nature of contamination introduced during trotter removal, the area of likely contamination was determined for carcass sites likely to be contaminated during dressing. Neck and hock areas were determined by measurement on 44 carcasses selected to represent the weight of lambs slaughtered in New Zealand. The area of the forequarter opening Y-cut and hind-leg opening cut was determined from Mills (2002) and Mills *et al* (2002b) and LeRoux *et al* (2003). In all cases, perpendicular cuts were assumed to result in direct contamination of an area of carcass surface area extending 1cm out from the cut line. The cut surface of the hock stub and neck were considered to be evenly contaminated.

Estimated areas and associated microbial contamination (APC) are presented in Table 6.

The contribution of the hock stubs (carcass surface and articular surface) of the hind legs to overall microbial contamination of lamb carcasses is log<sub>10</sub> 5.33 organisms. This is less than that contributed by the neck (5.45), but greater than that contributed by the foreleg Y-cut (5.05), hind-leg opening cut (5.03) and ventral opening cut (5.32). Furthermore, contamination of the neck is likely to be less due to flushing by blood and considerable trimming of meat around the neck area. Hock stubs processed with mechanical cutting directly through wool would contribute at least 23% of the contamination from the sources of microbial contamination described.

This concurs with the observations in the lamb carcass microbial mapping study (Mills *et al*, 2002b) that showed similar contamination levels for the hock (skinned trotter removal), neck, flank, lumbar and leg areas (Figure 2). Contamination around the anal area measured by the APC, if similar proportions to the *E. coli* count, will likely contribute substantially greater levels of contamination (Mills *et al*, 2002b).

While contamination during trotter removal will remain localized, hind legs are high value cuts, whether the hocks remain attached to the leg or separated, and are stored and shipped as prime vacuum-packaged chilled cuts (proportion shipped chilled/frozen depends on the company and market). In contrast, trunk meats from the neck area are usually frozen for storage and shipping.

The addition of a greater number of organisms to these high value chilled cuts without subsequent removal by trimming the skinned hock, or similar decontamination procedure, may well have an adverse effect on storage life. In effect, the through wool trotter removal procedure contributes to 66% of the bacterial contamination from the opening cuts on the hind leg, although that may be a lesser proportion if one accounts for likely contamination from the anal scallop cut.



Table 6 Estimated area contaminated (cm<sup>2</sup>) and microbial contamination (log<sub>10</sub> APC/cm<sup>2</sup>) of lamb carcasses during dressing using mechanical cutting through wool for trotter removal.

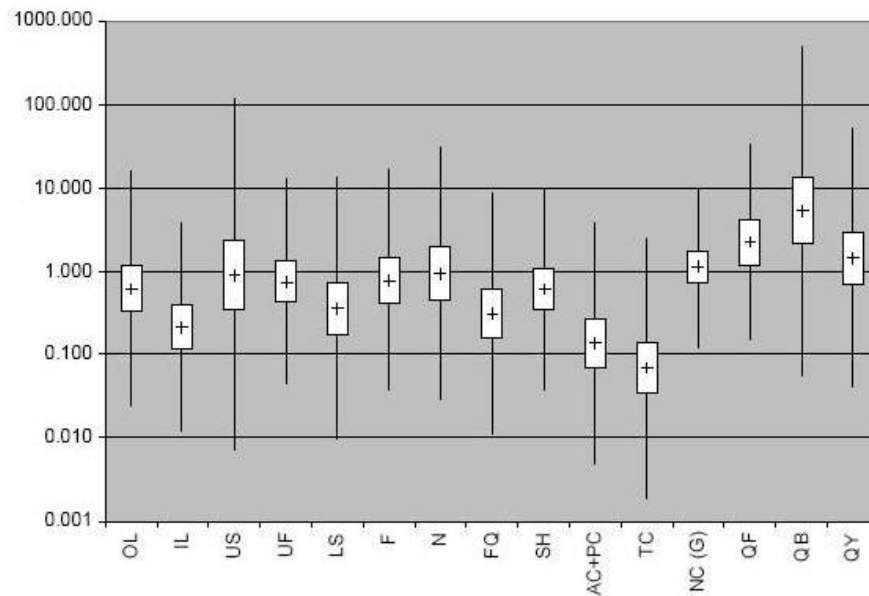
	Mean length of surface (cm) circumference (c), diameter (d), length (l)	Sides of cut retained	Retained contaminate d area (cm <sup>2</sup> )	APC (log <sub>10</sub> cfu/cm <sup>2</sup> )	APC per site (log <sub>10</sub> cfu/cm <sup>2</sup> )
Hock stubs (carcass surface)	11 (c)	1 x 2 legs	22	2.87	4.21
Hock stubs (articular surface)	3.6 (d)	1 x 2 legs	20	3.99	5.30
Neck (carcass surface)	25.7 (c)	1	26	2.87*	4.28
Neck (cut surface)	8.75 (d)	1	27	3.99*	5.42
Foreleg Y-cut	50.2 (l)	2	100	3.05**	5.05
Hind-leg opening cut	48 (l)	2	96	3.05***	5.03
Flap ventral cut	75 (l)	2	150	3.14**	5.32

\* In the absence of specific neck data, assumed equivalent microbial contamination to the hock at the end of processing.

\*\* National (all premises) data 1997-2006, n=61,132 <http://www.foodsafety.govt.nz/industry/general/nmd/>.

\*\*\* In the absence of specific hind leg opening cut data, assumed equivalent microbial contamination to the foreleg opening cut.

Figure 2 Geometric mean (“+”), 95% confidence limits (box) and estimated range (whiskers) for 95% of the data (i.e. 2.5 percentile to 97.5 percentile) of *E. coli* (cfu/cm<sup>2</sup>) from ovine carcass sites (Mills *et al*, 2002b). Key: Anal area (QB), inside hind-leg (IL), neck (n), shank (SH), flank (QF, F & UF), foreleg Y-cut (QY).



Most hock shanks are trimmed at the hock joint in the cutting room, thus removing the potentially contaminated articular surface, while fore shanks (knuckles) are generally packed untrimmed.

Any effect on food safety remains unknown although lamb shanks and leg roasts are generally well cooked prior to consumption.

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## 5 Conclusions

Regulations for dressing of lambs and sheep allow the removal of trotters using a "through wool" cut. However, a second cut must be made after depleting to remove the "contaminated" cut though wool surface of the hock stub; a procedure that imposes additional dressing costs on the meat industry.

This study shows that trotter removal by cutting through wool without subsequent trimming of the hock stub will compromise the hygienic status of lamb carcasses.

- The predominant visible contaminants remaining on the hock stubs after trotter removal are strands of wool up to 50 in number, and bone fragments likely very small in size. Trimming procedures were not fully effective in removing this visible contamination and it is therefore likely that up to ~40 % of shank stubs will remain contaminated with up to 25 strands of wool and up to ~10% contaminated with small fragments of bone.
- Mechanical cutters became 100-fold more contaminated ( $2 \log_{10}$  count increase) on contact with wool. It is likely that this high level of contamination would be transferred to the hock stubs and adjacent carcass meat during trotter removal.
- Microbiological contamination at or adjacent to the cut point was greater when the trotters were removed mechanically through partially skinned or unskinned hocks than when then the hock was fully skinned prior to manual or mechanical cutting. Nevertheless, contamination was localized as bacterial counts further up the hocks of fully dressed carcasses that had been processed using mechanical cutting through wool did not differ from those of the other procedure groups.
- Partial skinning of the hock prior to mechanical cutting offered no microbiological benefit.
- The hock stubs from long-wooled, dirty lambs were generally more contaminated than those with shorter or cleaner wool when trotters were mechanically cut through wool, although the  $0.5 \log_{10}$  count difference was statistically insignificant. Nevertheless, premises often sourcing wet, dirty, stock should take regard of possible adverse effect on carcass contamination and consequential effects on product quality and storage life.
- Hock stubs processed with mechanical cutting directly through wool contribute at least 23% of the overall carcass contamination from opening cuts on the legs and flap. Contamination around the anal area will likely contribute substantially greater levels of contamination to the hind-legs than the hock cuts.

- While the greater level of contamination of the hock stub with mechanical trotter removal through wool will remain localized, hind-legs and shanks are high value vacuum-packaged chilled cuts for which the addition of a greater number of organisms without subsequent removal by trimming the skinned hock, or similar decontamination procedure, may well have an adverse effect on storage life.
- Most hock shanks are trimmed at the hock joint in the cutting room, thus removing the potentially contaminated articular surface, while fore shanks (knuckles) are generally packed untrimmed.
- Any effect on food safety remains unknown although lamb shanks and leg roasts are generally well cooked prior to consumption.

It is concluded that the level of visible and microbial contamination on carcass meat when mechanically removing trotters by cutting directly through wool is significantly greater than that deposited after skinning.

The quality (e.g. visible contamination and storage life) and food safety consequences of these observations are unknown, especially where or when long-wooled dirty animals are more frequently processed. Mitigation would require additional procedures such as removal of a further length of the hock stub from the fully dressed carcass.

## 6 References

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