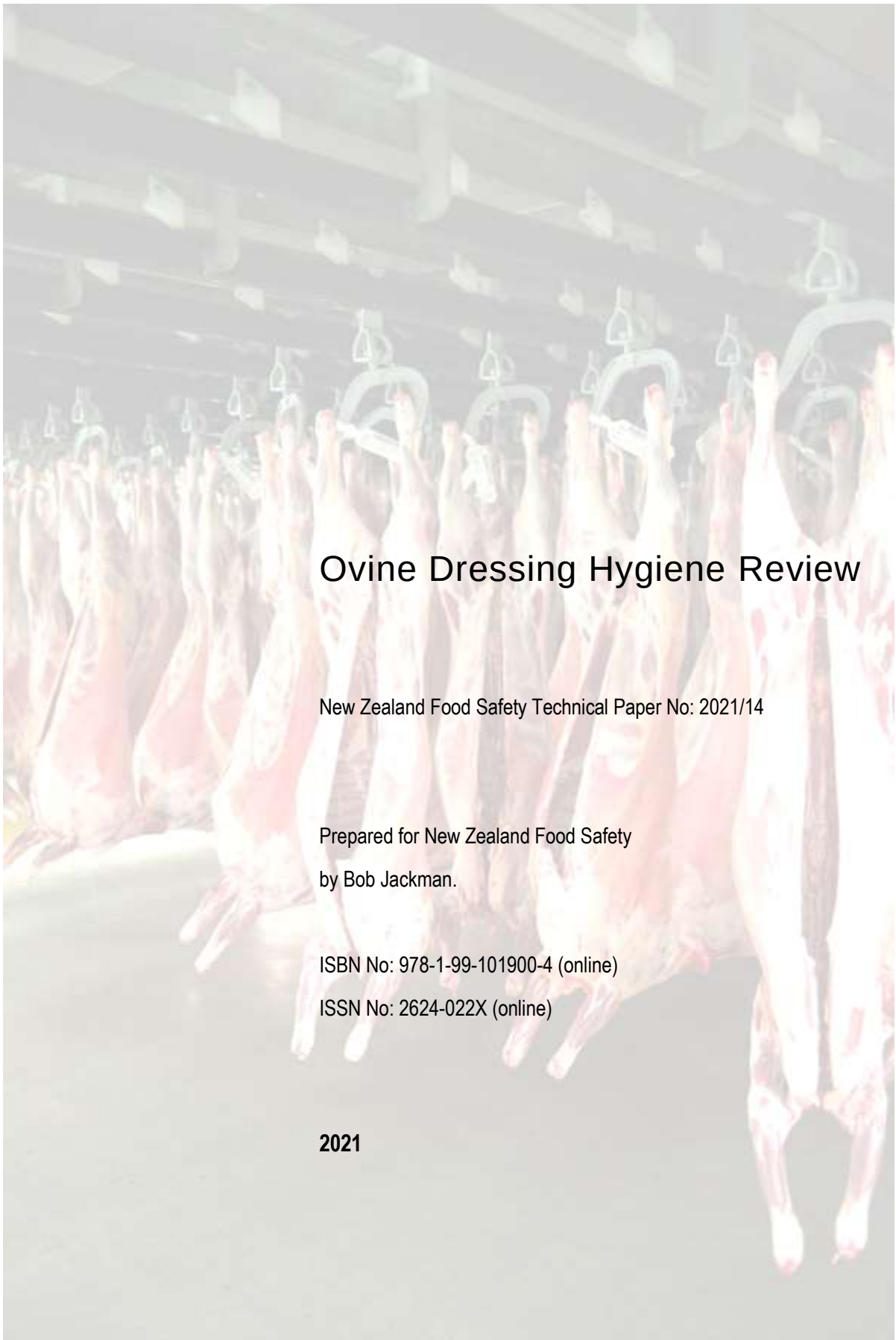
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Contents

1 EXECUTIVE SUMMARY 5

2 INTRODUCTION 6

3 PRE-SLAUGHTER 8

3.1 CLEANLINESS OF SLAUGHTER ANIMALS 8
3.1.1 New Zealand 8
3.1.2 International comparison 10
3.2 DRYNESS OF SLAUGHTER ANIMALS 10
3.2.1 New Zealand 10
3.2.2 International comparison 12
3.3 EMPTYING OUT OF SLAUGHTER ANIMALS 12
3.4 WOOL LENGTH OF SLAUGHTER ANIMALS 13
3.4.1 New Zealand 13
3.4.2 International comparison 13

4 PRE-SLAUGHTER WASHING OF OVINES 14

4.1 HISTORY 14
4.2 REGULATIONS AND GUIDELINES 15
4.3 SCIENTIFIC STUDIES 16
4.4 WASHING METHODS 17
4.5 NEW ZEALAND PRACTICE 18
4.6 INTERNATIONAL COMPARISON 19
4.7 WATER USAGE 20
4.8 ANIMAL WELFARE 20
4.9 INTERVAL BETWEEN WASHING AND PRESENTATION FOR SLAUGHTER 21
4.10 SUMMARY 21

5 SLAUGHTER FLOOR HYGIENE 22

5.1 HALAL SLAUGHTER 22
5.2 ISOLATION OF THE OESOPHAGUS 22
5.3 OCCLUSION OF THE OESOPHAGUS 23
5.3.1 Methods 23
5.3.2 Position of occlusion 23
5.3.3 International comparison 23
5.3.4 Discussion 24
5.4 RODDING 24
5.4.1 Position of rodding 24
5.4.2 Necessity of rodding 25
5.5 ON-CHAIN SHEARING OF CARCASSES 25
5.5.1 Discussion 25
5.5.2 International comparison 26
5.6 USE OF VACUUM DEVICES AFTER SHEARING 26
5.6.1 International comparison 26
5.7 BRISKET PATCH REMOVAL 26
5.7.1 Comment 27
5.8 Y-CUTTING PROCEDURES 27
5.8.1 Background 27
5.8.2 Comparison trial between scallop and spear cut Y-cutting techniques 29
5.8.3 Trial Results 30
5.8.4 Y-cut variations 30
5.8.5 Spear cut techniques 31
5.8.6 Pelt roll on opening Y-cuts 31

5.8.7 Pelt roll on brisket ... *31*
5.8.8 International comparison ... *32*
5.8.9 Discussion ... *32*
5.9 TRIMMING OF THE VENTRAL NECK ... 32
5.9.1 International comparison ... *33*
5.9.2 Discussion ... *33*
5.10 USE OF STEAM VACUUM DEVICES ... 33
5.10.1 International comparison ... *33*
5.11 CLEARING THE SHOULDERS ... 34
5.12 MIDLINE RIPDOWN ... 34
5.13 FLANKING ... 34
5.13.1 Pelt roll during flanking ... *35*
5.13.2 International comparison ... *35*
5.13.3 Discussion ... *36*
5.14 PIZZLE CLIPPING ... 36
5.14.1 International comparison ... *36*
5.14.2 Urine spillage ... *36*
5.15 ANAL SCALLOP ... 37
5.15.1 International comparison ... *37*
5.15.2 Discussion ... *37*
5.16 OPENING PELT OVER HIND LEGS ... 38
5.17 PELT ROLL AT HIDE PULLER ... 38
5.18 HANDLING OF CARCASSES ... 38
5.19 PRE-EVISCERATION CARCASS WASHING ... 39
5.19.1 International comparison ... *39*
5.20 IDENTIFICATION OF CONTAMINATION BY COMPANY ... 40
5.20.1 New Zealand ... *40*
5.20.2 International comparison ... *40*
5.20.3 Discussion ... *41*
5.21 TRIMMING OF CONTAMINATION PRIOR TO RINGING ... 41
5.22 TRIMMING OF CONTAMINATION BETWEEN RINGING AND CARCASS INSPECTION ... 41
5.23 TWEEZERS USED BY TRIMMERS ... 42
5.23.1 International comparison ... *42*
5.24 RINGING METHOD ... 42
5.24.1 International comparison ... *43*
5.25 BLADDER REMOVAL ... 43
5.26 LEAVING BUNG ATTACHED TO GASTRO-INTESTINAL TRACT ... 43
5.26.1 International comparison ... *44*
5.27 CARCASS MEAT INSPECTION ... 44
5.28 CARCASS HANDLING BETWEEN THE Y-CUT AND GRADING ... 45
5.29 ZERO FAECAL TOLERANCE ... 45
5.30 CARCASS INTERVENTIONS ... 46
5.30.1 International comparison ... *46*
5.31 TWO-KNIFE SYSTEM ... 46
5.31.1 International comparison ... *46*
5.32 TREATMENT OF WOOL AS A CONTAMINANT BY INSPECTORS ... 47
5.32.1 International comparison ... *48*
5.33 HAND WASHING BY INSPECTORS ... 48
5.34 STERILISATION OF KNIFE AFTER ENTERING BLIND CAVITY ... 49
5.34.1 International comparison ... *49*
5.35 REMOVAL OF MINOR AND MAJOR CONTAMINATION ... 49
5.36 TRIMMING AFTER FINAL INSPECTION – AUSTRALIA ... 50
5.37 POST DRESSING CARCASS WASHING AND SPRAY CHILLING ... 51
5.37.1 International comparison ... *51*
5.37.2 Spray chilling ... *51*

6 CONTAMINATION PATHWAYS MANAGEMENT (CPM) 52

6.1.1 Useful assumptions 52
6.1.2 Identification of contamination pathways 53
6.1.3 Management of contamination pathways 54

7 HACCP PROGRAMME 54

8 DISCUSSION 56

8.1.1 Presentation 57
8.1.2 Pelt removal 58
8.1.3 Trimming 58
8.1.4 Ringing 58
8.1.5 Post-mortem inspection 59
8.1.6 Zero Faecal Tolerance 59
8.1.7 Carcass Separation 60
8.1.8 Grading 60
8.1.9 Monitoring of processing 60
8.1.10 Contamination pathway management 61

9 CONCLUSIONS 61

10 BIBLIOGRAPHY 62

1 EXECUTIVE SUMMARY

Purpose

The preparation for slaughter and hygienic dressing of sheep and lambs in New Zealand was evaluated in all export slaughterhouses in New Zealand to determine the possible relative importance of the different process steps in contamination of the carcass. Processes in New Zealand were compared to those in nine other countries to identify different practices and assist in evaluation of opportunities for improvement under New Zealand conditions.

Methodology

Detailed observational studies of the slaughter processes at all ovine export slaughter premises in New Zealand were conducted in 2009 and repeated at twelve premises in 2019. These were complemented by observational studies at 30 ovine slaughter premises in nine different countries between 2007 and 2014.

The primary aim was to identify differences in processes that were considered likely to significantly impact on the microbiological contamination transferred from the pelt or gastro-intestinal tract to the carcass. Differing pre-slaughter and slaughter techniques that were considered likely to reduce carcass contamination were then assessed for their applicability to slaughter processes in New Zealand, resulting in recommendations for opportunities for improvement in the New Zealand setting. Note that not all observations are supported by definitive microbiological validation studies, but understanding of the pathways and mechanisms by which microbiological contamination occurs during processing is considered sufficient to support the recommendations.

Recommendations for improvement

Opportunities for improvement in minimising the transfer of microbiological contamination from the pelt/fleece to the carcass in New Zealand are:

1. **Pre-slaughter washing should not be routinely practiced**. Dry or damp presentation of stock will reduce microbial contamination of the carcass at opening skin cuts when compared to stock with wet or dripping fleeces. Reduced washing of animals will also have positive animal welfare outcomes and reduce water usage. Very dirty stock that needs to be washed prior to slaughter is best left to dry to minimise carcass contamination. It is noteworthy that New Zealand is the only country that routinely washes sheep and lambs prior to slaughter.
2. **Minimising contamination by changing the opening Y-cut technique.** Traditional Y-cut techniques using a spear cut inevitably result in pelt roll in and this is a significant source of carcass contamination. Use of a scallop cut rather than a spear cut and better attention to general hygiene will likely minimise carcass contamination at this site.
3. **Minimising carcass contact with contaminated hands.** Currently there are numerous opportunities for carcass contamination from contact with hands that are inevitably contaminated. This can be minimised by:
    - Use of tweezers or hooks rather than hands
    - Mechanical flanking
    - Reducing contact during regulatory inspection and industry inspections e.g., Zero Faecal Tolerance
    - Use of the gambrel or mechanical means for turning and moving carcasses.
4. **Use 'Option 3' carcass inspection to reduce routine carcass handling.** 'Option 3' is commonly referred to as "hands off" inspection and results in a significant reduction in

carcass handling by the official assessor, as most of the inspection is achieved through viewing rather than palpation.

5. **Using premises-specific carcass microbiological mapping.** Microbiological mapping of the carcass to determine the most contaminated areas in a particular slaughter and dressing process could facilitate targeted, meaningful interventions aimed at reducing overall microbial contamination.
6. **Use of the Contamination Pathway Management tool to evaluate a slaughter process.** This tool involves detailed observations of every step in the slaughter process to determine how microbiological contamination of the carcass is occurring and the likely pathways of this contamination spread around and between carcasses. Routine contact with hands, knives/equipment and sterilisation/washing routines need to be considered, along with any inadvertent contact with carcasses e.g., from personal protective equipment, upper arms etc. Other key factors are hygienic routines that occur between job rotations, training levels and supervision of workers, unexpected events, and deviation from documented job descriptions. Contamination pathway management could be improved if results from microbiological carcass mapping are available to inform of the most contaminated areas of the carcass.

Notwithstanding these recommendations, best hygienic practice in a particular processing setting will inevitably need to consider the proportionality of improvements brought about by specific actions relative to their practicality and cost, the consequential impact of actions taken at different steps in the processing system, and the final outcome sought in terms of an acceptable level of carcass contamination. Given these inputs, there is no "one size fits all" template for primary processing of all types and regional sources of sheep carcasses under New Zealand conditions.

2 INTRODUCTION

The public demand for safe food in the twenty first century and necessity for long shelf-life of chilled product to reach our markets make it imperative that the New Zealand meat industry continues to strive for improved hygienic dressing.

Historically, the main requirement for meat processors was to be supplied with animals that were suitable for human consumption in that they were free of disease and generally clean (i.e., were free of visible contamination). The processor was expected to manage any exception to these two conditions either before or after slaughter. In the twenty first century, with modern farming practices, the prevalence of diseased animals supplied to processors is now minimal and the major remaining challenge for the industry is to efficiently minimise the microbiological contamination risk that all slaughter animals may present to the hygienic production of meat.

Dressing procedures used by ovine processors in the New Zealand meat industry have evolved and been modified since chain processing began, with the country being at the forefront of improvements in processing techniques several decades ago with the development of inverted dressing of ovines. Since then however, in a number of processing and pre-slaughter steps, other sheep meat producing countries have made improvements and reduced the competitive advantage that New Zealand had enjoyed.

Along with inverted dressing, the development of mechanised flanking, hide removal and hock cutting have brought about improvements in carcass hygiene. However, the control of inadvertent microbiological contamination of carcasses during pelt removal, and to a lesser extent from spillage

from both ends of the gastrointestinal tract (GIT), remains a challenge for the industry. Recent advances in microbiological testing have increased the scrutiny that our products will come under, as has occurred with beef and bobby calf processing.

Any activity between arrival in the lairages and the conclusion of dressing that may increase the likelihood of carcass contamination should be closely examined.

One goal of this evaluation of ovine dressing hygiene in New Zealand was to compare the current procedures used by the industry against those used in other major sheep meat producing countries that have been visited by the author. Countries visited (and number of ovine establishments) to assess the hygienic dressing of sheep and lambs included Argentina (n=2), Australia (n=8), Canada (n=1), Chile (n=2), Iceland (n=3), Ireland (n=2), Norway (n=2), the United Kingdom (UK) (n=7) and the United States (US) (n=3). These overseas visits were conducted between 2007 and 2014. Comparisons presented in this report reflect the practices observed at the time of the visits.

The intention of this evaluation is to indicate which procedures may be likely to contribute to microbiological carcass contamination, with suggested alternative practices that should improve carcass hygiene. The selection of procedures is based on direct observation of the individual steps along the processing line as the first stage of Contamination Pathway Management (CPM). Those practices that provide the least opportunity for either direct or indirect contact between the fleece and the carcass, or from enteric contamination during evisceration are emphasised.

A survey of New Zealand's ovine slaughter and dressing practices was carried out in 2009 and revealed that in many areas along the production chain, there were a wide range of practices being employed by different processors. New Zealand's requirements for maximum shelf life and good carcass hygiene are arguably greater than most countries, given our distance from high-end chilled markets. An important objective of the Ministry for Primary Industries (MPI) is to encourage and assist processors in the development and refinement of procedures that will lead to a reduction of microbiological contamination of sheep meat and thus longer shelf life.

Twelve ovine processing plants were re-visited in 2019 and selected to provide a range of plant sizes, chain speed and post-mortem inspection options from both islands. The plants were observed with respect to their layout and procedures from lairages to the boning room, with an emphasis on detection of potential contamination pathways that could lead to unwanted microflora on the carcass. Every position on the slaughter floor was closely observed with each sequential action of the position noted.

Within the New Zealand (NZ) sheep meat industry, there are some processors who have taken on the concept of contamination pathway management, examined every step along the chain where improvements can be made to reduce contamination and introduced appropriate changes. In some cases they have also moved to Option 3 post-mortem inspection (a 'hands-free' option permitted by the Red Meat Code of Practice 7, Post-Mortem Examination). The challenge is for the rest of the industry to catch up to the best performers.

3 PRE-SLAUGHTER

3.1 CLEANLINESS OF SLAUGHTER ANIMALS

3.1.1 New Zealand

It is in the best interest of processors to be supplied with clean stock and to present them for slaughter in a condition that minimises the risk to carcass contamination when slaughtered and dressed. The ovine fleece carries a microbial population that on some animals may be greatly increased by contamination from soil and faecal matter. It has long been recognised that these contaminants provide the principal source of carcass contamination at slaughter (Biss and Hathaway, 1996a & b; Sheridan, 1998). More recent New Zealand work by Clemens and others (2010) confirmed that hygienic carcass dressing is of major importance to keep the potential for contamination with spoilage organisms such as *Clostridium estertheticum* to a minimum and thus maximise storage life of vacuum-packed chilled product.

Many factors that contribute to carcass contamination during slaughter begin with the supplier. Animals that are dirty and have long wool over the opening lines, which include the ventral neck, anterior and medial aspect of forelegs and midline belly, present challenges to the processor, although many farmers still pay most attention to the cleanliness of the hindquarters. The need for sheep and lambs to have clean, short wool along the opening lines has not been universally incentivised within the New Zealand meat industry. Other factors that influence the microbial load on sheep include animal husbandry practices prior to loading, the effect of transport and the season, as the proportion of psychrophilic microflora on carcasses increases in winter (Penney and Bell, 1994).

Almost all sheep and lambs supplied to New Zealand processors are raised on pasture. However, feedlot feeding of lambs has been trialled by some South Island farmers and may become more widespread in future. Judging by overseas experience, such animals are more likely than pasture fed lambs to accumulate faecal contamination on their hindquarters and bellies, and so may require more preparation prior to slaughter. It is acknowledged that break feeding of lambs over the winter months (common in the South Island) is a major contributing factor to dirty stock being presented for slaughter.

The responsibility for assessment of slaughter stock cleanliness has moved from the Government to the processor over the last two to three decades. The Meat Regulations 1969 (Reg. 89) stated that a person who offered any stock for slaughter for human consumption in any establishment that was in an unreasonably dirty condition committed an offence. However, an inspector could direct any such stock not to be slaughtered until rendered clean to his satisfaction. Since the introduction of the Animal Products Act (1999), the responsibility for deciding whether the supplied stock is sufficiently clean to slaughter is now that of the processor rather than the inspector, providing the processor can slaughter and dress the stock to the satisfaction of the MPI veterinarian on the day of slaughter. Industry Standard (IS) 4 section 4.3 stated that “the pelt or hide of animals shall not be grossly contaminated with soil or faecal matter before entry to the slaughter floor” and “It is recommended that the processor develop a programme for cleanliness of animals, or modified dressing procedures, using good hygienic practice (GHP) principles”.

Almost all export meat processors in New Zealand have outlined the standard of cleanliness that they expect lines of sheep and lambs to exhibit on arrival at their establishments. There is no one nationwide standard but most processors grade stock into three or four categories. The criteria include cleanliness or freedom from dags, maximum wool length over the whole animal and for some companies, whether the animal has recently had a belly shear, ring crutch and socks shorn.

For many years there has been a general understanding by suppliers that, if not recently shorn, lambs should at least be crutched (shorn above and around the tail) within a few days prior to trucking to the plant. Some suppliers crutch all lambs prior to transport to the plant; some crutch only those that are soiled while others do not crutch any lambs. Although the hind quarters of the animal are the one area most likely to be soiled with faecal matter, this attention to the cleanliness of the hind quarters, to the exclusion of the belly and forelegs, has continued in the mind of many farmers and livestock drafters who are possibly not aware that inverted dressing has shifted the opening lines from the hind legs to the forelegs and belly.

Although there is no regulatory requirement for sheep and lambs to be shorn shortly before delivery, some companies do encourage suppliers by means of a financial incentive to belly shear stock prior to transport to the processor. Since the value of wool compared to meat has decreased over previous decades, there has been less enthusiasm by suppliers to shear lambs prior to sending to slaughter but merely to carry out the minimum of preparatory work. Some companies pay for wool if not shorn but clean, while others pay an incentive for shorn sheep; these payments can be seasonal. What may not be understood by some suppliers is that inverted dressing is capable of hygienically removing the pelt from a lamb that has discrete areas of faecal soiling around the hind quarters provided the anal scallop cut and opening hind leg spear cuts (if carried out) can be made cleanly.

The propensity and willingness of companies to adhere to their own guidelines is flexible, depending on supply pressures and market demand. When supply is short, some companies are prepared to accept all sheep and lambs and prepare them after arrival to meet their own standards. Remedial activities taken by New Zealand companies when stock fails to meet their presentation guidelines, show considerable variation.

Of the 35 plants surveyed in 2009, 11 plants took no further action with dirty stock apart from rewashing them as many times as necessary (up to three times) and six of these plants used a swim wash to carry this out. Two premises would hose the dirty stock individually before washing or rewashing them. Seventeen plants were prepared to shear, dag or crutch those animals that failed to meet their standards in the yards as required. Only five companies would consider sending stock back to the supplier if they were too dirty, with just one company giving the supplier the option of coming into the yards and attending to the dirty stock at their own expense.

In 2019, only four of the twelve plants reviewed were dagging sheep in the yards (all South Island plants) and only two had ever returned stock to suppliers or arranged for the farmer to come to the premises and improve the presentation of their animals.

The challenge for the New Zealand meat industry is to increase the proportion of sheep and lambs arriving at premises fully prepared for slaughter without any further treatment apart from rest. If animals are only required to be moved through lairages prior to slaughter, rather than undergo more movement and discomfort, there should be an associated reduction in labour costs, water usage and stress to the animals.

Washing animals should be exceptional rather than routine practice.

3.1.2 International comparison

The cleanliness of sheep and lambs on arrival is recognised as an important facet of meat processing in all countries.

In Australia, sheep were presented for slaughter from the lairages after a suitable resting period. Although veterinarians performing ante-mortem inspection were the final arbiter of stock cleanliness, companies were expected to assess stock cleanliness and take any necessary remedial action. Two establishments were prepared to return stock to the supplier if they were in such a state that clean dressing could not reasonably be achieved.

In Canada, crutching was carried out if required although this was very rare since almost all animals were from a feedlot with strict standards of cleanliness prior to delivery to the processor. The feedlot operator was expected to crutch and belly-shear all lambs that did not meet the standard. In Chile, it was customary for all male lambs to be presented for slaughter entire and with intact tails. The animals were expected to be presented for slaughter clean and there was no shearing of lambs required or carried out, either before or after arrival at the lairages.

In Iceland, there was no treatment of any kind for animals prior to slaughter although this was in large part due to Icelandic sheep having very short tails that do not accumulate dags in the manner of long tailed sheep. In Norway all sheep were shorn in the yards prior to slaughter irrespective of their state of cleanliness and this was partially a consequence of sheep being left undocked in that country. One plant in Norway had moved the practice of shearing the sheep or lamb from the lairages to the slaughter floor while the animal was moved along the bleeding tunnel.

In the UK there was occasional shearing or crutching of dirty animals after arrival at most establishments, however an associated cost to the supplier of up to £1 by some processors had greatly reduced the number of animals requiring such attention compared to before the introduction of the practice. In only one establishment visited, were animals that were too dirty to process cleanly not accepted and returned to the supplier.

In the US, in two of three plants visited, animals were presented for slaughter that were ex-feedlot and were not free of dags around the hindquarters and along the midline.

3.2 DRYNESS OF SLAUGHTER ANIMALS

3.2.1 New Zealand

To optimise hygienic dressing following dry slaughter, suppliers must be encouraged to provide animals with short, clean wool over the opening lines. Those lines of animals that arrive in a state that precludes dry hygienic dressing need to be cleaned in a manner that does not increase the risk of carcass contamination.

Further advantages of dry slaughter include reduced water and labour cost in lairages, quicker stock movement through the yards as they only require resting rather than drying and resting, and reduced animal stress and improved animal welfare.

The animal presenting least risk to carcass hygiene while being dressed is one which is short wooled over the opening cuts and both clean and dry (Biss and Hathaway, 1996a). The moisture level of the fleece on ovines presented for slaughter is an important factor in determining the potential likelihood of microbial contamination of the carcass during dressing. Water serves as a vehicle for

bacteria, both between animals when washed in common water and from fleece to carcass during dressing.

Work carried out by Hadley and others (1997) in the United Kingdom clearly showed the importance of ensuring that meat animals presented for slaughter are as clean and dry as possible so that the microbiological contamination on the finished carcasses can be minimised. In their view, this would improve the shelf life of the product and reduce the risk of outbreaks of meat-borne food poisoning. Other previous authors (Leech, 1971; Patterson and Gibbs, 1978) also considered wet animals to be a greater risk to carcass hygiene than dry animals and recommended that animals should be allowed time at the abattoir to dry before they are slaughtered. This view was reinforced by Byrne and others (2007) who carried out research to identify the risk factors associated with the transfer of bacterial contamination from the fleece to the ovine carcass.

Although many lines of sheep and lambs do arrive with dry fleeces at establishments in this country, given New Zealand's temperate and pluvial climate there will also be many occasions when animals are wet from precipitation when either awaiting loading onto trucks at the farm, while being transported especially if they are on the top deck of an open truck, or from being left in uncovered holding yards at premises. The length of time that sheep will take to become dry when kept under cover depends on several parameters such as air movement, length of fleece and density of penning, with long-wooled and closely penned animals taking the longest to dry. There are differences between breeds of sheep in the time taken for wet animals to dry, which relates to the openness of the fleece. The location of the pens in the lairages and specific air flow around each pen will also influence the drying time.

The expectation that all ovines should be dry before processing would be difficult to achieve with the facilities currently available at most establishments. During periods of fine weather, incoming animals would arrive dry and clean lines could be kept dry until slaughter. However, this would not be possible during extended periods of wet weather over the stock catchment area and sufficient covered lairages would need to be provided for up to 12 to 24 hours, or even longer, to allow the animals to dry. There are several establishments in New Zealand which do have large, covered yards that could provide sufficient room for animals to be kept until dry, especially those large plants that have reduced the number of slaughter chains in recent years. Conversely, there are also many smaller establishments that do not have sufficient capacity to hold even one day's kill, let alone some of the following day's kill.

The use of air drying of lambs, underneath the animal just prior to slaughter, has been trialled by one company in New Zealand but has not been persevered with.

One argument used against the processing of dry sheep and lambs is that visible contamination is frequently seen on the abdominal flanks and forelegs as a result of dust and dirt being dislodged during pelting. Naturally this phenomenon is not unique to New Zealand but is often cited by processors as a reason not to slaughter dry stock. One solution to this problem is to accept that minor contamination is likely to occur and be present at the final carcass inspection point. In this scenario, it should not be regarded as a dressing fault and result in the carcass being detained. Instead, all carcasses could be trimmed on the main chain after final inspection at a series of trimming stations set up to give complete coverage of the carcass, as occurs in Australia. Any remaining minor contamination on carcasses from dry stock would be expected to present less risk to the carcass than would removal of wet and contaminated pelts.

Another reason often given for washing sheep prior to slaughter is to make it easier for the Y-cutters to grasp the fleece on the outside of the forelegs as they open up the pelt. This is countered by the fact that sheep processors elsewhere in the world appear able to manage such an incision without a damp fleece. Furthermore, this "difficulty" would not be an issue if scallop Y-cutting was carried out instead of using a spear cut.

One solution to make it easier to hold the pelt at the Y cut, as well as reduce minor contamination of the forelegs, would be to apply a short mist spray prior to slaughter to the legs of animals, possibly whilst in the conveyor.

3.2.2 International comparison

In all countries visited, if animals arrived in a wet state, they were retained until they were sufficiently dry. Differences existed in the facilities that individual plants had with regard to the effectiveness of drying pens. In some countries, premises were prepared to keep the animals for up to three days, which necessitated feeding, if that was needed to dry the animals. The usual guideline was that dampness was tolerated but no more moisture than that.

3.3 EMPTYING OUT OF SLAUGHTER ANIMALS

The risk to carcass hygiene is increased in those animals that are presented for slaughter with a full rumen compared to those animals with a near empty rumen. The weight of the entire gastro-intestinal tract is several kilograms heavier when full and consequently removal is made more difficult.

The minimum emptying out time is variable but is generally regarded as being ideally overnight, that is at least 12 hours. A survey (Fisher *et al*., 2012) carried out to investigate practices on sheep and beef farms in New Zealand, indicated that sheep were removed from green feed for 3–12 h prior to transport for slaughter with the stated duration longer amongst South Island than North Island respondents. The reasons that respondents to the survey gave for removing the animals from pasture included reducing the volume of effluent for transport operators, to allow sheep to empty out to prevent wool staining during transport, because sheep were better suited to load and travel when empty, it was required because of meat processor contractual obligations, and to reduce the impact of transport on carcass contamination and meat quality.

Most New Zealand farmers would appear to be aware of the link between transporting un-emptied animals and carcass contamination.

An Australian study (Pointon *et al.,* 2012) indicated that ideally stock should be fasted up to 24 hours prior to loading onto trucks to prevent soiling in transit and to not be fasted for more than 48 hours to prevent increased shedding of Shiga toxin-producing *Escherichia coli* (STEC). Given the much shorter transport distances in New Zealand compared to Australia, the upper limit is unlikely to be relevant to New Zealand processors.

The dilemma for both suppliers and processors is to balance the need for animals to be transported empty against animal welfare concerns and perceived weight loss. Suppliers are required to operate within constraints of time, weather and animal husbandry while the processor needs continuity of supply of suitably prepared animals. Customer expectations are also increasingly an important consideration for processors, particularly with respect to the animal welfare aspects.

The problem of stock inadequately emptied out is usually restricted to those lines brought into the establishment from suppliers who have either had insufficient notice of when stock is required, or who have failed to pen the stock off from feed for other reasons.

3.4 WOOL LENGTH OF SLAUGHTER ANIMALS

3.4.1 New Zealand

In relation to hygienic dressing, the wool length on the animal is most important over and adjacent to the opening lines where it may allow for contact between fleece and carcass during pelt removal. The other consideration with wool length is the effect that long wool has on extending the time required for the fleece to dry after washing, which in turn provides an enhanced environment for bacterial growth.

Biss and Hathaway (1995) showed that wool length was one of the pre-slaughter factors contributing to microbiological contamination of the lamb carcass. The mean aerobic plate count (APC) was higher on carcasses derived from lambs with a long wooled (and/or dirty) pre-slaughter status than from other carcasses. The pre-slaughter washing of long wooled lambs further increased the level of carcass contamination. Furthermore, at the end of the chill cycle, only pre-slaughter washing and long wool remained as significant factors associated with higher levels of carcass contamination. Another study (Field *et al*., 1992) was unable to demonstrate a deleterious microbiological effect on lamb carcasses due to wool length, although the length of shorn fleece wool was considered to be 2.5 cm. In New Zealand, shorn fleece is typically less than 1 to 1.5 cm and this could explain the difference between the two studies. A study by Duffy and others (2000) in the US suggested that preharvest practices, including shearing, appeared to have no major influences on APC, total coliform counts (TCC), and *E. coli* counts (ECC) on lamb carcasses. However, feedlot feeding and variable dressing and microbial intervention procedures in the US, compared to the New Zealand situation, may account for the reduced influence of wool length in that country.

A later study by Biss and others (1998) concluded that control of pre-slaughter presentation, particularly wool length, was confirmed as the most significant contributor to control of carcass contamination on lambs slaughtered in New Zealand.

3.4.2 International comparison

There is certainly no global consensus on the requirement for ovines to be presented for slaughter with short wool. It is generally preferred in New Zealand and Australia, but among the other countries visited, only Norway had a similar preference. The highest grade of stock presentation used in Australia included a wool length of less than 2.5 cm. Climatic imperatives influence the practice of shearing with it being used to reduce the likelihood of fly strike in warm countries and to encourage lamb growth in hot weather. In high latitude countries (such as Iceland, Norway and southern Chile and Argentina) it is considered unwise to shear sheep in the slaughter season (generally autumn) due to the risk of cold weather.

The ideal wool length for lambs was considered to be 2.5 cm by the largest processor in the UK. Some processors set the requirement for suppliers to shear along the opening cuts prior to delivery from autumn until spring and any sheep that arrive unclipped were clipped by the company at the supplier's expense. In one plant visited in Scotland, all sheep at any time of the year were required to be clipped between 50 to 100 mm either side of the opening lines. Any sheep not presented as such were clipped by a contractor and the farmer charged 75p.

In Norway, sheep were shorn immediately prior to slaughter. A study carried out in that country (Hauge *et al*., 2011) demonstrated that carcasses derived from shorn lambs had lower microbiological contamination by *E. coli* and lower APC levels than found on unshorn lambs. Comparisons between this contamination on carcasses from lambs that were shorn on the day of slaughter against that from those shorn three and five days before indicated that the shorter time from shearing to slaughter the less microbiologically contaminated were the carcasses.

At one plant in the US that processed ex-feedlot sheep, all supplied stock was required to be shorn over the opening cut lines. The practice was not required at the two other plants visited.

4 PRE-SLAUGHTER WASHING OF OVINES

New Zealand is the only country that routinely washes all sheep and lambs prior to slaughter.

Processors in Argentina, Australia, Canada, Chile, the European Union (EU), Iceland, Norway and the US preferred to process their sheep dry. Not only did these countries refrain from washing or wetting their sheep, but their processors took steps to ensure that ovines were no more than damp at slaughter.

Pre-slaughter washing is a long-standing practice in New Zealand and continues to be industry wide.

4.1 HISTORY

Prior to the early 1970s, all lines of sheep and lambs were inspected by meat inspectors in the yards and assessed as to whether they were sufficiently clean to be slaughtered without washing. If animals had been crutched by the supplier and were not unduly dirty, especially around the rear, they were processed without washing. Under the Meat Regulations 1969, the Director was permitted to issue such instructions as he considered necessary, having regard to hygiene, for the operation of washing facilities provided in yards of a type the Director approved as being adequate to effectively wash any class of stock (Regs. 37(d), 78). The Meat Regulations did not require all sheep and animals to be washed but forbade the slaughter of unreasonably dirty stock. An inspector had the authority to direct that any stock, which in their opinion was in an unreasonably dirty condition, not to be slaughtered for human consumption, unless and until the stock was rendered clean to their satisfaction (Reg. 89 (2)). Only those lines deemed unreasonably dirty by the meat inspectors were washed and in the case of disagreement between the company and the inspectors, the plant veterinarian was called upon to decide (J Novacek, pers. comm.).

In 1967, the United States enacted the Wholesome Meat Act and from then on, only meat that had been produced from any overseas plant listed as complying with their veterinary and meat hygiene requirements could be exported to the US. As a response to an increased intensity and level of criticism from US reviewers in the early 1970s, the washing of stock in New Zealand became commonplace and anecdotal evidence from that era indicates that one US reviewer insisted that only clean washed stock be slaughtered. The industry response was to install stock washes and swim baths at heavy cost (Robinson, 2006).

According to Calder and Tyson (1999), washing every sheep on arrival began as the personal idea of one US inspector during a visit to the South Otago Freezing Company Finegand plant near Balclutha and soon became a nationwide practice. It is noteworthy that washing of sheep and lambs prior to slaughter did not occur in the US even then. McKenzie stated in 1995 that “US and EU review officers

have also made personal judgements that have become enshrined in New Zealand [good manufacturing practice] GMP standards. In many cases, particularly those associated with biological hazards, the requirements have very tenuous linkages (if any exist at all) to human health and seem to be based on a perception of hazards without any direct relationship to the real risk to humans".

The washing of all lambs prior to slaughter would appear to be one of these unproven personal judgments.

Today, in terms of risk minimisation of product from paddock to plate, the management of ovines in the pre-slaughter stage is one of the continuing weaknesses of the New Zealand sheep meat industry. Whereby much attention has been paid by the industry over the previous few decades into ensuring that the farmer submits animals in the cleanest possible condition, at times this focus on supplier preparation has been countered by the industry's continuation of preslaughter washing as a standard practice.

By washing all animals, particularly in a swim wash, a line of lambs may be transformed from one including a proportion of animals with discrete areas of faecal soiling around the hind quarters to a line with higher microbiological levels on the fleece, including over the forelegs and belly, of all animals. Furthermore, the line will be microbiologically contaminated by all previous lines washed during that shift since the wash was filled with water.

Lines with some visibly dirty animals can be transformed into lines with invisible microbiological contamination of all animals.

By continuing with a procedure that is restricted to New Zealand, the meat industry may remain exposed to accusations of not following best practice regarding processing hygiene, animal welfare and water use.

4.2 REGULATIONS AND GUIDELINES

Most export slaughter premises in New Zealand are listed for export to either the US and/or the EU markets, so much of the guidance around hygienic dressing in the relevant industry standards or red meat codes of practice that might be optional for the domestic market is mandated for these export markets. The agreed industry standards relating to the washing of lambs and sheep prior to slaughter by processors in New Zealand are currently found in Industry Standard (IS) 4 where "the washing of any animals, when necessary, shall be carried out in accordance with a documented plan, refer to IS 4: Section 4.3, and be done in a manner that minimises any distress to the animals." (3.4.2: Washing of animals). In IS4 (Section 4.3: Condition of Pelt or Hide of Animals) the requirements include:

- that the pelt or hide of animals shall not be unreasonably dirty before animals are presented for processing into food (4.3.1)
- that the Licensee shall document a plan to ensure the condition of the pelts or hides of animals does not compromise the principles of hygienic dressing (4.3.2) and
- that animals with pelts or hides which are grossly contaminated with soil or faecal matter shall not enter the slaughter floor or processing room except where slaughter and dressing procedures have been specifically implemented to handle those animals with pelts or hides that are routinely contaminated, e.g., feedlot animals (4.3.3).

Furthermore, the development of a programme for cleanliness of animals, or modified dressing procedures, designed using the principles of GHP is strongly recommended.

The design of swim washes was initially modelled on the plunge dips that had been used on sheep farms for decades, with later developments involving the assisted entry and exit of sheep from these constructions being mechanised with conveyors. However, due to the questionable microbiological wisdom of immersing lambs in such water, many establishments have since trialled methods of washing sheep other than by total immersion and swimming; from spraying the belly from nozzles on the pen floor to cabinet spraying with detergent, allowing the animals to soak, then followed by total immersion and swimming to remove the detergent.

Some companies use overflow water from the sterilisers to both raise the temperature of the wash as well as save water. This practice may have microbiological ramifications if all material from contaminated knives is not inactivated.

4.3 SCIENTIFIC STUDIES

The relationship between pre-slaughter washing of sheep and lambs and the subsequent microbiological loading on the carcasses has been investigated previously in New Zealand.

In a study carried out by Biss and Hathaway (1996a) involving four slaughterhouses with contrasting dressing systems, the authors demonstrated that microbiological contamination with total aerobic bacteria and *E. coli* was greater on carcasses from animals which had been washed before slaughter, irrespective of wool length, and was generally higher on carcasses derived from woolly lambs than on those derived from shorn lambs. However, the effects of preslaughter washing on the forequarters compared with the hindquarters were not consistent, and this was attributed to differences between the two dressing systems used in the slaughterhouses.

Over all trials in the study, the mean total aerobic count ranged from 3.45 to 5.36 $\log_{10}$ cfu/cm², and the mean counts of *E. coli* ranged from 0.39 to 2.11 $\log_{10}$ cfu/cm². There was less visible contamination on the carcasses of washed lambs than on those of unwashed lambs. The differences in visible contamination with wool were largely dependent on the level of contamination of individual carcasses, whereas the differences in visible contamination with faecal material and dirt or sand were largely dependent on the prevalence of affected carcasses. The presence of visible faecal material or wool on the carcass was not associated with increased bacterial numbers on visually clean areas of the carcass.

This important finding indicated that the presence of faecal material or wool alone cannot be used as an indicator of the hygienic status of the carcass as a whole, particularly when using on-line monitoring parameters for Hazard Analysis and Critical Control Points (HACCP) systems. The authors concluded that the use of preslaughter washing to compensate in visual terms for poor preslaughter presentation resulted in a detrimental effect on microbiological loads on ovine carcasses.

Work carried out by Hadley and others (1997) in the UK confirmed the conclusions of Biss and Hathaway, and clearly showed the importance of ensuring that meat animals presented for slaughter are as clean and dry as possible so that the microbiological contamination of the finished carcasses can be minimised. In their view, this could not only improve the shelf life of the product, but also reduce the risk of outbreaks of meat-borne food poisoning. Other previous authors (Leech, 1971; Patterson and Gibbs, 1978) have also considered wet animals to be a greater risk to carcass hygiene than dry animals.

Biss and Hathaway later (1998) studied the relative carcass cleanliness of two different processing regimes where one entailed the processing of clean, shorn and unwashed lambs with an inverted

dressing system and the other involved dirty, woolly and washed lambs being processed in the traditional manner (i.e., where the hind legs were cleared first). The carcasses were sampled at four stages in the process: immediately after pelting, after dressing, after overnight chilling, and after final packaging. The dry inverted carcasses had low counts after pelting but these steadily and significantly increased through to final packaging, while the traditional carcasses had much higher counts after pelting that increased only slightly in the remaining stages. However, the APC for the final packaged meat was significantly lower on the hind legs and loins from carcasses from unwashed lambs compared to those from washed animals.

One interesting outcome of the latter study was that the authors noted an inverse relationship between the prevalence of carcasses with visible faecal contamination and their microbiological status. They concluded that the use of levels of visual faecal contamination as an on-line monitoring parameter for slaughter hygiene can give erroneous results.

These findings were confirmed by le Roux (1999) whose research indicated that bacteria grew rapidly on the wet fleece of swim washed sheep (probably due to high temperatures and the presence of sufficient nutrients) over the 18-to-24-hour post-washing period allowed for the animals to dry. It was also found that the transfer potential of bacteria onto carcasses was higher from wet fleeces compared to that from dry fleeces.

In summary, the single most important change that the New Zealand sheep meat industry could make to improve carcass hygiene would be to move away from routine washing of slaughter sheep and lambs, and to increase the proportion of stock slaughtered dry. New Zealand is the only sheep meat producing country that has routinely washed all ovines prior to slaughter for the last half century. Several studies carried out in this country have shown this practice to be likely to adversely affect carcass hygiene, and yet routine swimming of all lambs and sheep through contaminated water continues at some premises and many other premises routinely present wet stock for slaughter.

4.4 WASHING METHODS

Washing involves either moving sheep or lambs through a swim wash, usually assisted by conveyors at entry and exit points, or being sprayed from above and/or below. Sheep and lambs that have swum through contaminated water may appear to be cleaner. However, unless the water is frequently changed as opposed to continually topped up, inevitably there will be faecal contamination of the water from dislodged contamination and defaecation by the swimming sheep.

The water used by processors to wash sheep in the lairages is not required to be of a potable standard. The risk of this practice was further increased at one plant where the washing water is drawn from a river that is downstream of large-scale dairying operations and other sources of STEC.

Swim Washing

After immersion in a swim wash, there is likely to be an enteric bacteriological loading over the entire fleece of all such washed animals, rather than at specific areas on the fleece of some animals before they entered the wash. If they arrived at the lairages in a dry state, it is probable that these warm animals with damp fleeces covered with enteric organisms will have a more suitable environment for microbial growth after washing than on arrival.

A small number of scouring animals have the potential to microbiologically contaminate the fleeces of many.

For each animal, the level of fleece microbial contamination will depend on the time of day that they were washed and number of animals that have previously been through the same, albeit replenished, wash water. In some New Zealand plants, this may be up to 4,000 or more lambs before the water is changed.

If the animal is then slaughtered before the fleece is dry, which is common practice, the carcass is more likely to become contaminated with enteric organisms either through wool contact with the exposed carcass directly or through the operative's hands remaining contaminated by contact with the fleece, especially at the Y-cut and flanking stations. Those animals, prior to being washed, that had a low level of microbiological loading over the opening cuts are now more likely to have enteric bacterial contamination over these areas.

The dilemma for the meat industry is to be able to identify procedures that provide an acceptable and practical compromise between decreasing the presence of potential enteric pathogens and not dispersing the contamination of a few animals to many.

One of the prime objects of the Animal Products Act (1999) is to "minimise and manage risks to human or animal health arising from the production and processing of animal material and products by instituting measures that ensure so far as is practicable that all traded animal products are fit for their intended purpose" (Section 2 a). In order to meet the object of the Act, the company is required to use a risk management programme which, amongst other things, in relation to hazards "must demonstrate that the following matters have also been taken into account in its development:

- systematic identification of any hazards, and determination of the significance of those hazards, involved in the production and processing of animal material or product covered by the risk management programme
- determination of the points at which the hazards of significance identified in paragraph (a) occur, and the processes or procedures to best control them"

It would be difficult to describe the practice of swimming lambs through faecally contaminated water as being a procedure to best control the hazard of enteric fleece contamination.

Belly washing

Belly washing by spraying greatly reduces the spread of contamination between sheep and is less likely to increase the range and numbers of microbiological organisms on the fleece compared to total immersion in a swim wash.

Further developments in sheep washing systems have led to the use of a spray tunnel that uses recycled water in the first section of the tunnel, with detergent, and clean potable water in the second portion to rinse the contaminated water and material off the animals. Microbiological benefits, if any, have not been determined for this system.

4.5 NEW ZEALAND PRACTICE

A 2009 survey of sheep washing practices in New Zealand premises showed a wide variation in how sheep were prepared in the yards for slaughter.

Only two of the 35 export ovine establishments in New Zealand did not routinely wash all animals and at those two plants, fewer than 10% of animals were processed dry.

In the other 33 plants, all sheep and lambs were washed irrespective of their cleanliness on arrival. Seven establishments used a conveyor system when the animals were first soaked in detergent and left for ten minutes, then passed through a conveyor with spray nozzles from all directions. This water was recycled and changed every few days although at one plant, the water in the first section was left for up to one week before being changed. After passing through the first section of the conveyor, the sheep were then subjected to a spray of potable water (which was not recycled) to rinse off the water from the first wash.

Twenty-three establishments used a belly wash spray which involved spraying the sheep from the floor of pens for ten or so minutes at a time and some of these plants (n=12) combined the belly wash with a follow up swim wash. The belly wash was considered less effective against mud and faeces that were caked on to the belly and the swimming motion achieved by putting sheep through the swim wash was believed to assist in the removal of this extraneous matter.

Eight plants used a combination of spraying from above (generally by means of a boom spray) as well as a belly spray to clean the animals.

Three plants used hand-held hoses for the dirtiest sheep and lambs to complement the swim wash (n=2) or belly wash (n=1).

Nineteen establishments used detergent on all or some of the stock and this was usually applied as foam as sheep run through a tip spray race. Ideally the animals were left for ten to fifteen minutes for the detergent to loosen the contamination before they were subjected to either an overhead and belly spray wash or a swim wash.

Almost half of the ovine establishments (n=17) continued to use a swim wash for all or some of the animals and the frequency with which the water was changed varied considerably. For some plants, it was after 500 lambs had gone through the wash, for others the changing was done at the discretion of the operator but with no guideline apart from how dirty the water appears. At three large establishments, the swim wash was not emptied and cleaned out until the end of the day after which more than 4,000 lambs had swum through a body of water that had been continually topped up while presumably accumulating enteric organisms throughout the day. At one plant the wash was not emptied until the end of the night shift and was continually topped by the overflow from the sterilisers. At another low throughput plant the swim wash was emptied less frequently than daily.

However, these practices with regard to washing sheep prior to slaughter have evolved over the last decade. Since 2009, there has been a movement away from swim washing and towards using belly spraying instead. Of the 12 plants visited in 2019, only three plants were still using a swim wash, whereas six of them had been doing so in 2009. Detergent was used at five plants.

Another significant movement is that whereas in 2009, only two of the 35 plants ever processed clean, short wooled lines of lambs without washing, in 2019, of the 12 plants visited, four were now processing some lines unwashed.

For these four plants, this dry processing tended to be over the summer and autumn months and ranged from 5 to 20% of the daily kill.

4.6 INTERNATIONAL COMPARISON

The author is not aware of any other country that washes sheep or lambs prior to slaughter in North and South America, Europe, Scandinavia, and Australia.

4.7 WATER USAGE

Water usage is coming under greater public scrutiny and any reduction in use per animal should be an advantage in marketing terms.

For the 21 processing plants that were able to determine their water use attributable to ovine processing in 2009, the water used per animal averaged 0.43 m^3. However, there was considerable variation between plants in New Zealand with water usage ranging from around 0.2 m^3 per animal at two plants up to more than 0.8 m^3 per animal at two other establishments, with the latter both having a fellmongery on site.

Water usage per animal was not considered in the 2019 review. However, the observed reduced use of swim washing facilities over the last decade would suggest that the average water usage per animal slaughtered has reduced since 2009.

4.8 ANIMAL WELFARE

The fundamental obligations by processors in New Zealand towards slaughtered sheep were established by the Animal Welfare Act 1999, while the details are outlined in the Commercial Slaughter - Code of Welfare 2018 (MPI, 2018), which is based on the recommendations of the National Animal Welfare Advisory Committee (MAF, 2010).

In this document, the following points of Minimum Standard No. 4 – Handling of Large Mammals are relevant to the washing of sheep:

(p) All swim-washing and high-pressure or high-volume spray washing must be closely monitored at all times to ensure the welfare of the animals.
(q) Any animals that go under or swim in the wrong direction during swim washing must be assisted immediately.
(r) Animals must not be washed more than twice.

Recommended Best Practice

(e) Sheep should not be swim washed if the length of their fleece will result in unreasonable or unnecessary distress or injury during the swim wash process.

The Committee considered washing animals in the preslaughter period to be a major stressor. While it accepted the need for washing of some animals, the Committee recommended that washing should only take place when absolutely necessary. Furthermore, both climatic conditions and the body condition of the animals should be taken into consideration when the type and length of washing is considered.

The Committee also believed that development of improved methods of removing superficial contaminants in a manner that minimises the stress on the animal deserves a high priority. In particular, the Committee would prefer swim washing to be replaced by less stressful methods and suggested that future improvements are likely to include increased requirements for animals to be presented for slaughter in clean condition with their exterior free of faecal contamination and wounds.

An increasing challenge for the meat industry, as public scrutiny of all facets of meat production intensifies, is to be able to justify routine washing of all sheep and lambs. If sheep are not being washed for cleanliness but to facilitate the Y-cutting and reduce minor contamination on the

forelegs, then there are other solutions to these problems that could be developed to meet both carcass hygiene and animal welfare aspirations, such as minimal spraying of legs prior to slaughter.

4.9 INTERVAL BETWEEN WASHING AND PRESENTATION FOR SLAUGHTER

There is no industry standard for this interval, and it is generally governed by expediency and the need to keep the chain full. A rule of thumb in the past has been for companies to ensure that animals are at least “drip dry” and preferably “squeeze dry” where no water can be expressed from the fleece when firmly squeezed. Over the last two decades, a trend in ovine slaughterhouse construction has been for lairage capacity to be reduced and more reliance to be placed on “just in time” delivery of animals. This is a concept borrowed from warehousing that may well work in theory but often less so in the meat industry where, for a number of reasons, in practice, stock are not delivered as anticipated.

This requires effective coordination among the company stock buyer, trucking firms, and suppliers. Farmers need sufficient notice to muster, draft, and withhold their stock from pasture to allow emptying out. If there are unanticipated and late withdrawals from supply, with no buffer of yarded animals for the company to slaughter, this may mean insufficient notice to the next supplier and consequently, lines of lambs with a full rumen arriving just before slaughter. The consequences of full lambs being unloaded, then washed immediately and then slaughtered within minutes are not conducive to good carcass hygiene.

Of the 12 plants visited in 2019, all had a minimum of 30 minutes of drying time before presenting for slaughter with nine plants prepared to wait up to an hour if drying took longer. For most yard supervisors, the decision on when to put lines up for slaughter was left to an assessment of each line and communication with the slaughter floor to establish whether the lines already put up were sufficiently dry. Pen location, wind speed and direction along with the ambient temperature were all factors that affected drying time.

This situation is an improvement from 2009 when of the 35 plants surveyed, there were nine plants prepared to put stock up for slaughter within 30 minutes of washing and three of these would put them up within 5 minutes of washing if they needed to keep the chain running. At these plants, expediency over-rode carcass hygiene considerations. Of the other plants, 13 were prepared to wait for a minimum of 1 hour, 11 plants insisted that sheep remain for at least two hours or more between washing and slaughter and only two premises were not prepared to present sheep and lambs within 12 hours of washing.

The slaughter and dressing of animals with wet fleece is particularly hazardous to carcass hygiene, especially those animals that are unshorn and have woolly socks. When wet animals are suspended by all four legs, water from the feet and pasterns will drain towards the area of foreleg that is to be opened up during the Y-cut procedures. The likelihood of microbial contamination of the forelegs is considerably increased for those carcasses that are dripping wet.

4.10 SUMMARY

While washing selected lines of animals that are soiled (faeces and/or mud) along the opening lines is still necessary if shearing is not available, the routine immersion of sheep and lambs in contaminated water (‘swim washing’) prior to slaughter is an outdated practice, is not used in any other sheep meat producing nation and is arguably an unnecessary risk to carcass hygiene for the New Zealand

meat industry in the twenty-first century. Regardless of the washing process, microbiological contamination of carcasses is more likely if the sheep are processed with wet fleeces.

5 SLAUGHTER FLOOR HYGIENE

The guidelines provided by MPI to the meat industry are to be found within Chapter 5 of the Red Meat Code of Practice which state that:

> "(3) Dressing must be carried out hygienically and in a way that manages the potential distribution and proliferation of contaminants [HC Specs 13.7(5)].
>
> The key components of the dressing process that must be managed include:
> a) the de-hiding or de-pelting or hair removal operations
> b) evisceration
> c) cross-contamination.

However, any further guidance as to what management of contamination entails is not provided and the onus is on the meat industry to develop their own procedures to meet the responsibility that they have taken on. For processors to develop effective management of contamination, it is imperative that they understand by what action each worker, from stunning to grading on the slaughter floor, may contribute to the microbiological loading of carcasses.

5.1 HALAL SLAUGHTER

The method of halal slaughter used in New Zealand is one that has been developed over recent decades to meet both religious and animal welfare concerns. The coincidental severing of the oesophagus that results from the practice is accepted as an unavoidable consequence of the single outside-in incision made through the skin, trachea, oesophagus and blood vessels.

At one US sheep plant visited by the author, halal slaughter was effected by a single inside-out incision made from the side of the neck that severed the jugular veins and one carotid artery but not the oesophagus. The oesophagus was then clipped prior to the distal end being severed which prevented the discharge of rumen contents which sometimes happens after the carcass is suspended. However, at this premises, the chain speed was less than 3 per minute and the precision required to carry out this technique may be difficult to achieve at higher speeds.

Since halal slaughter usually involves an outside-in incision and transects the oesophagus, it is unavoidable that some contamination from fleece and ingesta is likely to reach the adjacent exposed neck muscle. However, a neck trim is routinely carried out at most premises and it is unlikely that the halal incision contributes significantly to contamination of the carcass if this occurs.

Of the 12 New Zealand plants visited in 2019, only one did not carry out halal slaughter at that time.

5.2 ISOLATION OF THE OESOPHAGUS

This operation involves placing an inside-out incision from the halal incision to below the sternum to expose the oesophagus and trachea, freeing one from the other and pulling it out. The possibility of pelt roll and contamination from ingesta is an almost unavoidable consequence of this operation.

It is usually carried out just after the halal slaughter incision has been made and at only one of the 12 plants visited in 2019 was the oesophagus isolated after the Y-cut. At this plant, the extended period

after the oesophagus has been severed may allow for more ingesta to be released, but the area of carcass most likely to be contaminated (tongue root and surrounds) is removed with the head and neck trim.

5.3 OCCLUSION OF THE OESOPHAGUS

5.3.1 Methods

A) The traditional method of occluding the oesophagus was by tying a knot at the distal end of the severed oesophagus. Usually, an incision was made into the musculature about 5 cm from the end to ensure that the knot was more likely to remain in place as the oesophagus was pulled through the mediastinal attachments and diaphragm during evisceration.

   This method was still used at one plant of the 12 visited in 2019.

B) The first advance in occluding the oesophagus in New Zealand slaughterhouses was the introduction of the rubber ring which followed its introduction as a method of castrating male lambs in the 1960s. The rubber ring was an improvement on tying a knot but still suffered from occasional slippage. It could be pushed up the oesophagus by using a rodding device after the oesophagus had been cleared of any attachments in the thoracic cavity by the same device.

   Of the 12 plants visited in 2019, only two were using the rubber ring.

C) The most common method of occluding the oesophagus over the last two decades is by using a purpose made plastic clip which can only be moved in one direction. It is clipped around the distal end of the oesophagus then pushed proximally towards the thoracic opening. The clip is then pushed further up the oesophagus towards the diaphragm in the same manner as for the rubber ring described above. When correctly applied, this system of occluding the oesophagus has close to zero failures when the abdominal viscera are removed.

   This method was used by the remaining nine plants visited.

5.3.2 Position of occlusion

The most common position to occlude the oesophagus is directly after its isolation and before the onset of the Y-cut. This occurred at nine of the 12 plants visited in 2019. At two plants, the oesophagus was isolated before or at the beginning of the Y-cut and occluded after the operation, while at one plant, the oesophagus was isolated and occluded after the completion of the Y-cut.

The different positions of the occlusion operation do not appear to have any significance with regard to carcass contamination, provided neck trimming is carried out effectively.

5.3.3 International comparison

This is an area of dressing innovation in which New Zealand has shown leadership. The development of the plastic oesophagus clip (commonly referred to as a weasand clip) in this country has greatly reduced the incidence of occlusion breakdown and is now being used in many other countries including Argentina, Australia, Chile, Iceland, Norway, the UK, and US.

One sheep premises visited in Canada and one of the three visited in the US were still knotting the oesophagus after performing the Y-cut, while in the UK one plant was still using rubber rings. In the UK, two premises did not occlude the oesophagus until after the hide puller.

There was only one processor visited where the oesophagus was not occluded. This was an establishment in Norway where ovines were eviscerated in the inverted horizontal position (suspended by the forelegs) and the oesophagus was severed at the diaphragm.

5.3.4 Discussion

As soon as the oesophagus is severed by the halal incision, there is the possibility of the contents (ingesta) extruding out of the oesophagus and onto the exposed neck tissue. The likelihood of ingesta extrusion is affected by the fullness of the rumen and the position of the suspended carcass. There has been some suggestion that the parameters of the immobilising current may also influence the likelihood of ingesta escaping from the severed oesophagus.

To occlude the oesophagus, the operator must first incise the skin over the neck by spear cut, reflect the skin, incise between the trachea and oesophagus to free the latter which may then be isolated and occluded. Most establishments arrange for the oesophagus to be occluded as soon as practical, but with some chains this is not possible until after the carcass has left the immobilising rail or tunnel. For this operation, the carcass is suspended by both fore and hind legs, providing some relief from the downward pressure of rumen contents, which will be higher when a carcass is hanging by its hind legs only.

The importance of effective occlusion of every oesophagus is critical as ovine establishments move to change their system of meat inspection from hands on (Option 1) to hands off (Option 3). The one region that will not be viewed by meat inspectors under Option 3 is the ventral neck and cranio-dorsal thoracic cavity, which is the region of the carcass most likely to be contaminated by ingesta in the event of an occlusion failure, or before occlusion. Extruded material that visibly contaminates the distal neck can be effectively trimmed while the forelegs are still on the spreaders but the prevention of any extrusion of lumen contents is the preferred outcome. Routine neck trimming during pluck (contents of the thoracic cavity) removal will remove most contamination by ingesta.

5.4 RODDING

This procedure is to clear the oesophagus from any attachments within the thoracic cavity to facilitate evisceration. It is carried out by grasping the distal end of the oesophagus, placing a metal loop around it then pushing the loop up the oesophagus towards the diaphragm so as to free it from any attachments it has to the trachea and mediastinal tissue. The metal loop is either attached to the tip of a knife or to a specific tool which doubles as an applicator for pushing a rubber ring or plastic clip up the cleared oesophagus as well as a knife. This procedure has been an industry standard since before the traditional knotting of the distal oesophagus was superseded by the introduction of rubber rings. It was found to greatly reduce the incidence of knots unravelling during gutting.

5.4.1 Position of rodding

The most common position along the chain for the rodding operation was shortly after the completion of the Y-cut (nine plants). At six plants, the oesophagus was isolated and clipped before the Y-cut with rodding being carried out later, while at three plants the rodding immediately followed the isolation of the oesophagus after the Y-cut.

At the remaining three plants, the oesophagus was isolated, clipped and rodded before the Y-cut.

The different positions of the rodding operation did not appear to have any significance with regard to carcass contamination.

5.4.2 Necessity of rodding

New Zealand processors may wish to discover whether indeed they still need to rod the oesophagus. Given the evolution of sheep dressing procedures, it is possible that the need for this task has diminished since rubber rings have been replaced by clips.

At one sheep processing establishment visited in Norway, the oesophagus was not cleared before or after application of the oesophagus clip. Instead, before the clip was applied, the oesophagus was pulled firmly once or twice. This tugging was sufficient to break the fibrous attachments in the thoracic cavity so that after the oesophagus clip was attached and pushed up to the first rib, the abdominal viscera were able to be removed with little extra effort and without the clip moving or the oesophagus breaking.

Similarly, one ovine establishment visited in Ireland did not rod and clear the oesophagus but instead pulled the oesophagus, as in Norway, and knotted the end. Apparently plastic clips had been trialled previously and found to be no more effective.

If the ease of lifting and removing the abdominal viscera was similar with both techniques, the necessity of rodding would diminish. The removal of any procedure from the current sheep dressing process would potentially generate savings to the industry.

5.5 ON-CHAIN SHEARING OF CARCASSES

This procedure involves shearing the sheep or lamb over those parts of the pelt that are to be opened during the Y-cut and rip down procedures. This is from pastern to pastern on the front legs and from the sternum to inguinal region on the belly.

Of the 12 plants visited in 2019, four were carrying out some degree of shearing on the slaughter floor with three of them shearing the opening lines between the brisket and forelegs and the fourth processor shearing the belly and hind leg opening lines only. This operation is carried out after the oesophagus has been rodded at three plants while in the other premises, it is carried out immediately after the halal foreleg lift position.

Two plants were routinely shearing all animals while the other two were only shearing long woolled lines. Only one establishment was routinely shearing along all the opening lines of all ovines while another plant was routinely shearing lambs only above the perineum region and up the inside of both hind legs where an opening spear cut is to be made, but not along the Y-cut opening lines.

5.5.1 Discussion

Shearing sheep and lambs on the slaughter floor has been intermittently tried in New Zealand plants over many decades but invariably most have discontinued the practice. One of the contributing factors to shearing being dropped was the subsequent problem of increased numbers of carcasses being detained for clumps of short wool. When the practice was used along the hind legs above the opening cut in the traditional dressing procedures, it was carried out just prior to the pelt over the hind leg being opened without any attempt or time to remove the shorn wool.

The introduction of shearing on the slaughter floor is seen as a useful adjunct to carcass hygiene but one that requires an effective method of removing loose wool and preventing it falling onto the opening cut lines.

This represents a more targeted approach to reduce carcass contamination where the intervention is directed to the area of concern only as opposed to pre-slaughter washing where the entire animal is treated regardless of what part of the animal specifically requires attention, if at all.

5.5.2 International comparison

The author is not aware of any shearing of sheep or lambs on the slaughter floor in other countries except for one plant in Norway that shifted in 2009 from using the traditional practice in that country of shearing all sheep in the lairages to shearing the entire animal on the slaughter floor after sticking while the animal moves along the bleeding tunnel. The procedure was carried out by up to eight workers with a hand piece, each shearing a different area of the animal. It was not followed by any vacuuming for loose wool and, according to the veterinary technical advisor on the plant, there had been no increase in the incidence of loose wool, dirt or grit on the carcass as a result of the change from shearing in the lairages.

5.6 USE OF VACUUM DEVICES AFTER SHEARING

Of the four establishments out of the 12 visited that have incorporated shearing into their dressing procedures, three of them have greatly reduced the problem of loose wool falling onto the forelegs at the Y-cut by using a powerful vacuum device just after the shearing operation and before the forelegs are lifted onto the spreaders. Furthermore, the use of the vacuum has also reduced the problem of loose grit reaching the forelegs of the carcass and lowering the incidence of minor contamination. The diameter of the vacuum tube is also sufficient to be able to insert the foreleg past the elbow into the tube if deemed necessary by the operator.

This method of removing loose wool and grit is seen as particularly effective as it is preventative, targeting the problem before the pelt is removed without contributing to any increase in fleece contamination.

Robotic removal of shorn wool was operating in one of the plants visited although the proficiency of the device did not appear to be as effective as hand-held vacuums due to inconstant direction and distance from the skin. At this plant, removal of strips of skin by the preceding shearer allowed for direct contact between the vacuum nozzle and the exposed carcass, which was not conducive to hygienic dressing.

5.6.1 International comparison

Of the premises viewed in Argentina, Australia, Canada, Chile, Iceland, Norway, the UK, and the US, none were using vacuum devices on the animal prior to pelt removal when visited.

5.7 BRISKET PATCH REMOVAL

This procedure involves the removal of a strip of pelt from over the brisket (sternum) prior to the opening cuts on the forelegs. The procedure is usually carried out with a specialised curved knife with a blunt knob tip to prevent carcass damage. The sequence of incisions involves a transverse outside-in incision at the navel end of the sternum followed by a vertical downwards inside-out incision on both sides of the sternum. This allows for the pelt covering the brisket to be removed by pulling the flap downwards, often by using both hands.

Another method seen in the UK began with the opening cut above the brisket being made by a scallop cut from just below the navel to just past the xiphoid end of the sternum leaving the 8-10 cm wide strip hanging. The patch was extended as described above to the sternum end of the brisket. By

holding the scallop cut in one hand, and pushing with the other, the patch of skin is removed. There is some occasional wool contact onto the exposed brisket, but the benefit of the operation was seen as facilitating the shoulder clearance after the Y-cut and minimising pelt roll behind the axillae.

This procedure is not carried out in New Zealand and was not used in plants visited in Argentina, Canada, Chile, Ireland, the Netherlands, and Norway. It was observed in all plants visited in the UK and in some plants visited in Australia, Iceland, and the US.

5.7.1 Comment

There is a range of opinion amongst meat hygiene regulators in different countries about the merits of the procedure. Some plant veterinarians felt that it did help to minimise pelt roll while others were not convinced. With dirty animals and poor technique, the procedure appeared to adversely affect carcass hygiene.

Poor examples of workmanship observed included a horizontal cut outside-in above the sternum through faecal contamination, no sterilisation of the knife after this cut or between the downward incisions either side of the brisket and contact between unwashed hands, a dirty brisket flap and the carcass.

The outside-in incision above the brisket would appear more likely to introduce pelt and fleece contamination to the brisket than would occur when the brisket was cleared back following the Y-cut as is performed in New Zealand.

This procedure is not currently recommended as an aid to carcass hygiene in New Zealand.

5.8 Y-CUTTING PROCEDURES

5.8.1 Background

When the meat processing industry of New Zealand moved from traditional to inverted dressing in the 1980s, the standard method of pelt opening changed from a scallop cut over the hock towards the anus, completed by a flat spear cut along the hind leg, to that of a spear cut from sternum to knuckle of the foreleg. The spear cut method was deemed to be a technique that minimised contact between wool and the exposed forelegs especially on long wooled lambs (Guidelines to Hygienic Dressing Techniques (Ovines) MAF 1994). This guidance was issued to accompany Industry Standard (IS) 5 and the intention of the publication was to remove many of the prescriptive techniques from the Meat Manual 5 and replace them with statements of principle.

It acknowledged that contentious interpretations had been made about the various means to achieve the principles and stated that the photographic guideline that had been prepared in conjunction with the Meat Industry Association (MIA) was an attempt to rationalise the boundaries of acceptable practices. The procedures for ovine dressing techniques in IS5 and the possible methods of opening the pelt were subsequently described under section 5.3.5, which allowed for the pelt to be opened by either the skin being opened with a small cut and then using a spear cut to extend the incision, or by removing a strip of skin provided that there is no sawing motion of the knife.

However, despite the guidelines being purported to describe statements of principle without being prescriptive, IS5 Section 5.3.5. concluded by stating: “the use of this technique is limited to removal of the scrotum, udder, and skin around the anus”. Thus, despite two options being available for some

areas of the pelt, the New Zealand meat industry was restricted to the use of the spear cut for the Y-cut.

According to one of the contributors to the 1994 Guide to Hygienic Dressing Techniques (Ovines) the industry rationale was that the scallop cut was seen as being inefficient while the spear cut could be done rapidly at fast chain speeds, and as long as the butcher didn't ring the hock at the end of the first leg, he could continue onto the second leg without washing (P. Ward, pers. comm.).

In the guidelines, it was stated that it was not possible to routinely and economically remove the pelt without some wool contact, but the principles were designed to minimise this contact. The same standard was described for both short and long wooled sheep although it was suggested that extra care or procedural modification may be necessary to dress long wooled sheep in a hygienic manner. The guidelines also stated that as a general principle, light contact of the tip, or some of the shaft, of the wool staple was acceptable provided it was obvious to an observer that all practical steps were taken to minimise the contact. The guidelines continued by stating that inversion of pelt (also known as roll-back or roll-in), irrespective of the degree of wool contact, was avoidable and unacceptable.

Since the change to inverted dressing within the New Zealand meat industry, there has been much regulatory attention given to the exact manner in which the ovine pelt has been opened over the forelegs and whether pelt roll is occurring or not. Over three decades of inverted dressing has seen the Y-cutting operation continue to be a contentious area due to the conflict between what is required (no pelt roll) and what is possible, even by experienced slaughterers, when asked to perform the Y-cut by a method that is predisposed to causing pelt roll.

The industry standard procedure by which the operator clears the pelt from the forelegs, neck, and brisket is by using a spear cut whereby the tip of the knife is introduced under the pelt at the point of the sternum and pushed towards the distal end of the limb with the blade kept at right angles to the pelt. This procedure requires considerable experience and attention by the operator to complete the manoeuvre in one motion without the blade leaving the pelt on each leg. It is more difficult to perform on long wooled animals and usually the fleece adjacent to the incision line is held by the operator's non-knife hand in several successive places as the incision is continued upwards from sternum to pastern.

This extra contact with the fleece associated with the spear cut technique in long wooled sheep and lambs was not considered when the two methods were originally compared.

For many plant veterinarians acting for the competent authority, any blade angle used on the Y-cutting procedure which is not at right angles to the skin constitutes a dressing fault and requires correction by the company. However, most operators are of the view that the Y-cutting procedure is impossible to achieve on a high-speed chain without a blade angle of less than right angles on occasions, especially over the knuckle and towards the carpal joint. A survey of veterinarian opinion of Y- cutting techniques has confirmed the reality of this practice. This spear cutting method inevitably allows pelt roll to occur on that side of the incision that the blade undercuts, as the edge of the incised pelt withdraws from the incision line. Even when the blade is held at right angles to the skin surface and moved distally along the foreleg, the skin is often elevated and separated from the underlying fascia as it is incised, which allows the skin to retract from the incision line, roll over and allow the fleece to contact the carcass.

The reduction of the number of sites that are monitored on the lamb carcass for the National Microbiological Database (NMD) programme from three over the carcass to just one on the foreleg

has significantly increased the importance of the Y-cutting procedures with respect to the assessment of hygienic dressing. Given that the manner in which the pelt is first opened over the neck and forelegs is likely to have a significant bearing on the microbiological status of the carcass in those areas, the precise method of opening the pelt over the forelegs should be of particular interest to the processor.

More recently, increased domestic regulatory flexibility has been introduced. The Red Meat Code of Practice Chapter 5 (Slaughter and Dressing) does permit the option of the scallop cut to open up the forelegs during the Y-cut under its guidance on dressing techniques (p. 9):

> 7) The skin should be reflected before incisions are made into the carcass.
>
> a) Examples of valid opening techniques are:
>
> i) the skin may be either opened with a small cut, then a spear cut used to extend the incision (blade directed outwards), or a strip of skin may be removed (provided that there is no sawing motion of the knife).

Close observation of the scallop cut technique shows that natural elasticity of the skin, especially adjacent to the humerus, brings about a retraction of the sides of the scallop cut so that an initial scallop width of 2 to 3 cm leaves a 3 to 4 cm wide strip of exposed foreleg. Because there has been minimal raising of the skin when the scallop cut was made in comparison to the spear cut, and no undercutting of the pelt, there is much less opportunity for pelt roll to occur as the cut edges of pelt are still attached to the underlying fascia.

5.8.2 Comparison trial between scallop and spear cut Y-cutting techniques

A comparison of the microbiological effect on carcass hygiene between the two methods of opening up the pelt over the forelegs and neck was carried out with slaughter lambs in a New Zealand slaughterhouse over late winter and spring of 2009. The lines of lambs that were selected to be microbiologically assessed over the six-week period varied in wool length from recently shorn (less than 20 mm in length) to unshorn (over 50 mm). Some lambs had woolly “socks” while others had very little wool over the lower limbs. The period of the trial (carried out on each Monday from late July to mid-September 2009) was chosen to cover a time of the year when animals that were wet and muddy on arrival were not uncommon, and thus would be during the most difficult time of year in which to dress lamb carcasses cleanly.

For the period of the trials, the operators used the scallop cut method from the start of the day and the sampling was always carried out on lambs that were processed after four hours of using the new technique. This sampling delay was to allow the operators the time to develop their scallop cut technique so that they were able to achieve a level of skill and consistency that would provide a meaningful comparison with the spear cut method.

The method of scallop cutting the Y-cut that evolved, and preferred by almost all operators, was where the pelt was held and tented over the proximal end of humerus and a long strip of skin approximately 2 to 3 cm wide was removed beginning at this point and finishing distal to the knuckle (metacarpal) joint of each foreleg. There was a minimum of sawing knife movement as the strip was removed. After the scallop cut, the opening of the foreleg was completed by means of a spear incision from the beginning of the scallop cut back towards the point of the brisket (sternum).

After at least four hours of dressing in this manner, ten carcasses randomly chosen from the identified line were swabbed in the NMD proscribed site on the foreleg on the slaughter floor.

Another randomly chosen five carcasses from the selected lines were similarly swabbed prior to leaving the chillers the following day as a post chill assessment.

5.8.3 Trial Results

The post slaughter microbiological assessment of those carcasses dressed by means of a scallop Y-cut during the trials revealed them to have a mean APC of 2.84 $\log_{10}$ cfu/cm², which was less than the average APC measure of carcasses dressed by the conventional spear cut over the same period (3.01 $\log_{10}$ cfu/cm²).

The improvement in carcass hygiene was still evident after chilling. For the post chill microbiological assessment of the carcasses dressed by using the scallop Y-cut, the mean APC over the trial period was 2.73 $\log_{10}$ cfu/cm² which compared favourably to the carcasses dressed by using a spear Y-cut technique (mean APC of 3.11 $\log_{10}$ cfu/cm²).

The primary objective of the trials was to establish the microbiological benefit of using a scallop cut to open the pelt over the forelegs and this was demonstrated to be the case by the results. The other advantages reported by the operators of performing the scallop cut, which included ease of technique, minimisation of pelt roll and faster clearing of the forelegs were not assessed microbiologically as those areas likely to be affected by pelt roll are on the lateral, posterior and medial aspects of the forelegs, which are not directly covered by the standard NMD swabbing procedures.

The conclusion of the trial was that, compared to the scallop cut, the spear cut method of opening the forelegs inherently leads to more pelt roll and thereby an increased likelihood of carcass contamination through contact with the fleece.

5.8.4 Y-cut variations

Although the purpose of the Y-cut procedure is the same for all ovine processors, the manner in which that was achieved varied from plant to plant, with differences to the sequence of incisions and pelt removal along with the inclusion of a number of other associated steps. At two plants the Y-cutter began by breaking the neck and at three plants the operation began by shifting a foreleg to another spreader. At eight plants, the operators moved along with the carcass as they worked while at three plants, each operator remained at one station and completed their allotted work as the carcass moved past them. At one plant, the first operator was stationary while the next three workers moved with the carcass.

The number of operators in the Y-cut group ranged from two to six with the variation a reflection of the chain speed and number of tasks that had been incorporated in the “Y-cut” operation. Almost all Y-cut butchers at the plants visited were right-handed (n=40) and only one was left-handed while the direction that the carcasses moved past the butchers was evenly split with six moving left and six moving right. This aspect of the Y-cut was included as a possible contributing factor with respect to carcass hygiene if a butcher was completing the clearing of the leading leg at the end of his routine with his preferred knife hand being on the trailing side.

Only two of the plants cleared the leading foreleg first with most (n=10) clearing the trailing leg first.

All operators used a spear cut to open up the forelegs although, at one plant, the spear cut on each leg was followed by a scallop cut that removed a 3 cm wide scallop of pelt from the base of the foreleg to above the knuckle. At this plant, the Y-cutter did not continue to clear each foreleg but instead that was left to the following shoulder clearing by way of flay knives which continued up from the neck to clear each foreleg without any handling of the pelt as happens with conventional leg clearing. This technique would appear to be a more hygienic method in that even careful grasping

of the cut edge of the leg pelt is often accompanied by contact between the operator's finger and thumb and the exposed carcass.

At five plants, the Y-cutting also included fully clearing the brisket and laying it back with a mechanical roller, while at another five plants the brisket was only partially cleared by the Y-cutter and the operation was completed by those clearing the shoulders after the Y-cut. At two plants, the brisket was not cleared until after the conclusion of the Y-cut operation. Most plants (n=8) used a roller to clear the brisket, after an initial freeing by knife to provide sufficient pelt to insert in the roller, while at the other four plants the brisket was freed by using a flay knife. Hygiene lapses commonly observed during the Y-cut included a failure to sterilise the knife between spear cuts (six plants, although at another four plants the knives were rinsed once or twice during the process) and contact between the hand that held the pelt when performing the opening cuts and the exposed carcass.

5.8.5 Spear cut techniques

A survey carried out in 2009 by plant New Zealand Food Safety Authority (NZFSA) Verification Agency (now known as MPI-Verification Services) veterinarians at the 35 ovine establishments showed that, in their opinion, the operators performing the Y-cut opening incisions are using a flat knife routinely or frequently (n=4), quite often (n=12) and occasionally (n=11), despite years of attention from regulators to ensure the knife blade is at right angles to the pelt. A "flat knife" is the term used to describe the position of the knife relative to the pelt surface where the angle between the pelt and the blade is less than 45^{o}. Given that butchers will modify their technique while being observed, and an understandable reluctance by veterinarians to report the extent of poor hygienic dressing at their plant, the true incidence of the flat knife technique at the time was likely to be higher than what was reported.

During the 2019 review, it was obvious that use of the flat knife technique is now universally used rather than the blade being at right angles to the pelt.

Unless directed otherwise, butchers will revert to what technique is easiest and it is apparent that the most common procedure is to use the flat spear cut from sternum to above the knuckle with one side of the incision (the left side for right-handed operators) being undercut, making it easy to lift to clear the socks but more prone to pelt roll and carcass contamination compared to the scallop cut.

5.8.6 Pelt roll on opening Y-cuts

At the 12 plants visited in 2019, pelt or fleece contact with the exposed carcass during the Y-cut operation was observed for most carcasses at 10 plants, with less than half of carcasses potentially contaminated at only two plants. It was more frequent on long wooled lines as long damp wool has sufficient weight to flop back on to the carcass after the opening cut.

With the spear cut method of carrying out the Y-cut, it appears that contamination of the adjacent areas on the foreleg is unavoidable.

The challenge for the processor is to ensure that the consequences of this contamination are minimised.

5.8.7 Pelt roll on brisket

The review showed that pelt roll on the brisket is not as prevalent as that observed on the forelegs but is still sufficiently common to be a possible contributory factor to carcass contamination. Several factors influence the likelihood of pelt roll from the brisket, including the degree of clearance around the axillae, the length and weight of wool over the brisket flap, the degree of care in placing the

brisket flap back and the relative height of the rear and front spreaders. Where the forefeet are above the level of the hind feet, a reflected brisket is more likely to stay in place.

5.8.8 International comparison

There are a range of practices used to open the pelt on ovines globally. The traditional system of ovine dressing whereby the pelt is removed by first opening up the hind legs was observed in one plant in both Canada and the US. In both plants a scallop cut was used to open the hind leg from pastern to anus.

All other countries and plants visited, including two in the US, used the inverted dressing system.

In Australia and Iceland, both the scallop and spear cut techniques were observed at different plants with the scallop cut used more frequently. In Argentina and Chile, the spear cut method was used in all plants. In Ireland, the Netherlands, and the UK, only the scallop cut was used. Both plants in the US that had inverted dressing both used the scallop cut. In Norway, the scallop cut was used to open the forelegs from the knuckle to elbow joints and then completed with a spear cut to the sternum.

Of the two alternative procedures, the scallop cut was the most common method of performing the Y-cut in the countries visited.

5.8.9 Discussion

Given that the way the pelt is first opened over the neck and forelegs (known as the Y-cut) is likely to have a significant bearing on the microbiological status of the carcass in the adjacent area, the precise method of opening the pelt should be of particular interest to the sheep meat industry. Prior to pelt removal, the underlying lamb tissue is considered to be sterile due to the inability of microorganisms to penetrate the fleece/hide (Nottingham and Brown, 1982; Gill and Baker, 1998; McEvoy *et al*., 2004).

The reduction of the number of sites that are monitored on the lamb carcass for the NMD programme from three to one (at the Y-cut site) reflects the increased importance of the Y-cutting operation and its relationship to monitoring overall process hygiene.

It appears that pelt roll over the forelegs while putting in the opening cuts is more than an infrequent occurrence at most of the ovine plants in New Zealand, and this must be a direct consequence of the practice of using a spear cut to open up the forelegs. At most of the plants, the knife is not held at the vertical plane with the ensuing undercutting of one side of the incision and attendant pelt roll.

In conclusion, both international practice and trial work in New Zealand strongly indicate that the spear cut method of opening the forelegs unavoidably leads to pelt roll and thereby an increased likelihood of carcass contamination through contact with the fleece. When the fleece has had an increase in microbiological contamination through pre-slaughter washing (as demonstrated by Biss and Hathaway, 1996a), the use of the spear cut would appear to be even more unhelpful and indeed counter-productive in reducing carcass contamination.

Serious consideration should be given to exploring the option of using a scallop cut technique to open up the pelt on the forelegs.

5.9 TRIMMING OF THE VENTRAL NECK

This procedure is generally carried out after the forelegs and shoulders have been cleared and the carcass is still hanging from both sets of spreaders. It is frequently the last operation for the rodder

to cut through the distal oesophagus and trim the neck in one movement. At some plants, the neck trim is carried out either after the flanking operation, or at pluck (contents of the thoracic cavity) removal.

Cutting through the oesophagus while trimming the neck in one movement carries the risk of contaminating the remaining neck muscle, and at four of the 12 plants visited, the operator sterilised their knife after cutting through the oesophagus and before completing the remaining neck trim. This is likely to result in lower microbiological contamination of the neck.

5.9.1 International comparison

The neck trimming was routinely carried out in Australia, Iceland, Norway, and Scotland. In Australia, the neck was trimmed either just before or after the final hide puller and usually in conjunction with the hocks being shortened. In Iceland neck trimming was routinely carried out, either after Y-cut on the spreaders, or before the hide puller, while in Norway the neck trim was left attached to the pluck on removal of the latter. There was no routine trimming of the neck in Chile, Canada, England, Ireland or Wales, or in two of the three plants visited in the US.

5.9.2 Discussion

Those plants that do not routinely trim the neck while the carcass is on the spreaders may still carry out some trimming as the pluck is removed from the hanging carcass. As the heart and lungs are withdrawn from the thoracic cavity, the operator will free the trachea by running the knife down between the trachea and the ventral neck. This procedure generally removes most of the possible sites of contamination by ingesta but has two drawbacks. Firstly, more time has elapsed compared to trimming after the Y-cut for the contaminated end of the oesophagus to disperse any residual ingesta. Secondly, the trimming site is not able to be viewed by the operator as it is carried out to assess its effectiveness and whether all visible contamination has been removed.

Contamination of the remaining neck muscle from the blade as it passes through the oesophagus (when carried out prior to pluck removal) is possible and the operator can reduce the likelihood of microbiological contamination by sterilising the knife immediately after transecting the oesophagus.

From a hygienic perspective, the earlier site of routine neck trimming, where the neck is viewed and trimmed while on the spreaders, is the preferable option and particularly helpful when using Option 3 post-mortem inspection.

5.10 USE OF STEAM VACUUM DEVICES

These are used by some companies to remove wool, loose dirt and grit that falls onto the forelegs and axillae during the clearing process of the forelegs and shoulders, but usage is still not universal within the New Zealand ovine meat industry. The hot steam should also reduce the microbiological population on the carcass surface where applied.

In 2019, only three plants out of the 12 visited were steam vacuum devices being used and these were deployed to cover the opening lines along the forelegs and brisket. With any staff shortages, this operation was one that is frequently dispensed with.

This is one area where more widespread use could improve carcass hygiene.

5.10.1 International comparison

In Australia, most of the plants visited used steam vacuuming devices at different stages such as after the Y-cut, prior to the final hide puller, after the final hide puller, after the changeover and after final

inspection. In Canada, only the hind quarters were cleaned by steam vacuuming after the forelegs were dropped and prior to the midline pelt being split.

Neither plant visited in Chile used any steam vacuuming device. The procedure was not used in Iceland, while in Norway one plant used steam vacuum devices on the carcass both pre-evisceration and post inspection. In Ireland and the UK, steam vacuuming was not used on the slaughter floor although one UK processor had tried it as a means of removing loose wool.

In the US, in one plant the entire carcass was subjected to steam vacuuming prior to pre-evisceration washing while at another the procedure was applied at seven locations along the chain: after Y-cutting on forelegs, after hide puller on abdomen and flank, after final carcass inspection on hind quarters and abdominal wall, and on the brisket after carcass wash. The third company did not use any steam vacuuming devices but used whole carcass spray with hot water and lactic acid instead.

In general terms, the use of steam vacuuming devices is more commonly used in New Zealand, Australia, and North America and either sparingly or not at all in South America and Europe. The latter could reflect the traditional European disinclination to apply water to the ovine carcass at any stage of processing.

5.11 Clearing the shoulders

This operation involves grasping the freed pelt of each foreleg (known as a “sock”) and/or the skin from around the neck and pulling to free the pelt from the entire foreleg and shoulder. If this operation is performed while the carcass is still suspended by four legs, the operator will be positioned behind the carcass and pull the foreleg pelt backwards and downwards. If the operator is overly vigorous when pulling one side, there is a possibility of the pelt on the other side flicking forward, rolling in and contacting the exposed neck. This is more commonly seen when the operator is struggling to keep pace and having less time to be careful.

At one plant visited, the shoulder was sufficiently cleared by air knife at the end of the Y-cut operation that no further shoulder pulling was necessary.

5.12 Midline ripdown

This operation is performed after the forelegs have been cleared and the carcass has reverted to being suspended by the forelegs. Ideally the spear cut incision is performed with the knife being sterilised after each separate incision, which was observed at eight of the 12 plants visited.

Pelt contact with the carcass was apparent at five of the plants, where the edge of the pelt rolls in a manner that allows fleece to contact the exposed carcass. On these carcasses, contamination is likely to occur on the abdominal wall along the midline.

5.13 Flanking

This stage of ovine dressing refers to the clearing of the pelt from the ventral and lateral abdominal aspects of the carcass from the already cleared brisket and shoulders to the inguinal region. The procedure has been traditionally done manually although around half of ovine processors were using mechanical devices in 2019.

The manual procedure involves punching down with the fist adjacent to the midline/rip down belly incision and using the forearm to lever the remaining attached pelt off the abdominal wall. It is standard practice for the operator to wet his fist and wrist just prior to punching down to facilitate

the movement; a dry fist being much harder to push between the pelt and the carcass surface. The flanking procedure is one that involves some risk to carcass hygiene. As the pelt is cleared over the abdominal wall and rib cage, contact between the fleece and the operator's forearm, and then between forearm and brisket is not uncommon. Microbiological contamination of the fist, forearm, and elbow is hard to avoid and effective washing of the arm from hand to elbow is time consuming, awkward, and rarely seen routinely. In those plants that do not wash carcasses either pre-evisceration or post dressing, this operation is the only one that applies water to the abdominal wall of the carcass which may encourage microbiological growth in that area. On some chains in New Zealand, the flanking procedure is preceded by the operator using both hands to pull down the pelt (sock) to clear the foreleg prior to the flanking operation and, despite rinsing of the hands, will also contribute to carcass contamination. The routine involves holding the fleece with the non-punching hand which is then used to punch down the other side. The hand will be rinsed as required, between the fleece contact and then carcass contact, but microbiological contamination will occur regardless of the rinsing.

The mechanical devices being used to complete the flanking operation in New Zealand plants (also known as "thumb tools" and "hockey sticks") are less likely to contaminate the carcass and can be sterilised between carcasses. They are vertical hydraulic rams with a short horizontal section or "thumb" that is guided between pelt and carcass with one hand while the fleece is held by the other. The pelt can be held away from the carcass as it is separated and carefully released to ensure there is no fleece contact with the carcass.

The number of workers required to carry out the flanking operation is determined by the chain speed. On medium to high-speed chains, generally two operators are employed to flank one side each. At slower chain speeds, one person may be responsible for flanking both sides.

Of the 12 plants visited in 2019, six plants used a mechanical thumb and five flanked the animals manually. At one plant, the hide puller was able to remove the pelt without any clearing of the pelt adjacent to the midline incision. Of the six plants using a mechanical thumb, at only two plants did the worker sterilise the thumb between carcass sides.

Of the five plants where flanking was carried out manually, at only two plants did the worker clear one side of each carcass and wash their hands between carcasses. At the remaining three plants, the flanking was carried out by either one worker, or two on alternate carcasses, who did not wash their hands between sides and so routinely contaminated the abdominal wall, particularly the second side.

5.13.1 Pelt roll during flanking

Pelt roll during the flanking procedure was observed at only two plants, both of which used mechanical flanking, and in both cases involved the operator releasing the pelt in a manner that made contact with the carcass more likely.

5.13.2 International comparison

In Australia, both manual and mechanical means of flanking were observed. At two plants the flanking was not carried out as a separate operation and the abdominal area was cleared by two workers pulling the pelt downwards from behind prior to a first stage hide puller being used.

In Argentina and Chile, only manual punching was used as more value was placed on the integrity of pelt than on the microbiological cleanliness of the abdominal wall.

In Canada and the US manual punching of the flank was used in their traditional hind leg first dressing systems however mechanical flanking was used in the two inverted dressing plants.

In Iceland and Norway all premises used mechanical flanking.

In the UK, mechanical flanking was used in all but one of the premises visited. The sole establishment still flanking by hand had a chain speed of less than one lamb per minute.

5.13.3 Discussion

This is one area of ovine dressing where some processors in New Zealand have not kept up with best practice and could improve their carcass hygiene by converting to mechanical flanking, especially those chains that use only one operator to perform the flanking. The key difference between the two systems is that the mechanical device can be sterilised between sides and carcasses.

Manual flanking is more likely to result in carcass contamination with bacteria from the fleece over the belly when compared to mechanical flanking.

5.14 PIZZLE CLIPPING

The purpose of occluding the pizzle (penis) is to prevent urine spillage over the carcass, more specifically over the hind legs after the pizzle has been freed from the abdominal wall and left suspended. Generally, carcass contamination by urine is rare due to the flow of any urine being directed between the hind legs while the carcass is suspended by the forelegs. However, during and after inversion of the carcass at the gambrel-up / changeover workstation, there may be some urine spillage over the abdominal wall.

The standard position for the pizzle to be occluded is after the removal of the scrotum and testes (known as the cod cut) before the hide puller.

Of the 12 plants visited in 2019, at only five premises was the pizzle being occluded with two plants using oesophagus clips, two using white plastic ties and one using a crushing device. This a reduction in the proportion of premises that were undertaking pizzle clipping from back in 2009 when the survey showed that the pizzle of lambs was being routinely clipped (n=24) or cauterised (n=2) in 26 of the 34 establishments that process male lambs. Of the other eight plants, the pizzle was only clipped if leaking was observed prior to the changeover (n=3), sometimes (n=3) or not clipped at all (n=2).

There has been a shift away from routine clipping and instead using a method of identifying those carcasses where leakage has occurred, which can be attended to by identification and trimming.

5.14.1 International comparison

In most countries visited, that is Argentina, Canada, Chile, Iceland, Ireland, Norway, the UK, and the US, the pizzle was not clipped or occluded.

However, in Australia, all plants visited clipped the pizzle with a one-way plastic clip with all but one plant clipping prior to the final hide puller. In Chile, the processors claimed that by having all stock arrive on the day before slaughter and only providing chlorinated water for drinking, the bladder was only half full in most animals and unlikely to cause spillage at dressing.

5.14.2 Urine spillage

This phenomenon was an unintended consequence of inverted dressing whereby during the pelting process, with the carcass suspended by the forelegs and experiencing increased abdominal pressure as the pelt was removed, the incidence of urine escaping from the urethra has increased. The

incidence of urine spillage also appears to be line related, but whether this is due to physical parameters such as time spent in yards with access to water, or a genetic propensity, is unknown.

Routine clipping of the pizzle would help avoid urine spillage in male lambs in those plants not already doing so. All plants used a ticket system to identify those carcasses affected by urine spillage so that the affected areas can be trimmed further down the chain.

5.15 ANAL SCALLOP

This refers to the practice of removing a circular or oval section of skin around the anus of the animal at any stage of dressing prior to the hide puller. The removal of skin should be done in such a manner as to leave the anal sphincter intact and thus reduce the likelihood of faecal material being ejected during hide removal. The operation is facilitated using modified pliers to grasp the skin piece prior to incision.

This practice is routinely carried out in New Zealand ovine premises and was required under IS5, where section 5.3.15 stated: "*the anal area shall be completely cleared. The anal sphincter shall be left intact if water is applied to the carcass before dressing is completed*".

The removal of the anal scallop was carried out in all but one of the 12 premises visited in 2019, with the procedure carried out prior to the Y-cut at five premises and afterwards at six premises.

At only one plant did the operator sterilise his knife immediately after cutting over the anal sphincter and before continuing to clear the underside of the tail; this would appear to be best practice if the anal scallop is completed.

5.15.1 International comparison

This procedure was not carried out in Australia, Canada, Ireland, Norway or the UK. In one of the three plants visited in the US, the anal scallop was removed by the operator hanging up the carcasses after sticking, without using pliers. It was not carried out in the other two plants.

In Argentina, at both plants visited, the anal scallop was performed. In Chile one plant carried out the anal scallop while the other used a single 2-3 cm incision along the perineum ending 1.5 cm above the anus which served the same function as an anal scallop. Chilean processors were very conscious of the value of their pelts and so unlikely to carry out any procedure that damages them.

In Iceland, two out of three plants carried out the procedure opposite the Y-cut operation by using pliers. In both the Chilean and Icelandic processing plants, the practice of using an anal scallop had been introduced by New Zealanders, either in management or as slaughterers.

5.15.2 Discussion

This procedure, if carried out incorrectly, can be responsible for faecal contamination around the exposed hind quarters during pelt removal and prior to the changeover to suspension by the hind legs. If the anal sphincter is removed either partially or completely, there is no barrier to faecal pellets being extruded as pressure is increased on the abdominal contents during pelt removal.

Processors could investigate whether the Chilean method of a single incision leaving the anal sphincter intact is sufficient, or whether the Australian procedure of not carrying out an anal scallop at all is possible and does not result in pelt strain or carcass contamination under New Zealand conditions.

5.16 Opening pelt over hind legs

Compared to 2009 when most ovine plants opened the pelt up along the inside of the hind legs, only four of the 12 plants visited carried out this operation in 2019. The main reason for these incisions is to prevent or reduce the permanent stretching and distortion of the pelt that may occur with some types of hide pullers which in turn reduces the value of the pelt.

During periods of low pelt value, the hind legs tend to be unopened by processors.

The technique involves opening the pelt over the inside of the hind legs by means of an inside-out spear cut incision between the inguinal opening scallop and the hock joint.

In the past, one establishment minimised the procedure needed to reduce stretching by restricting the pelt incision to a scallop cut from the hock joint to the foot. This is a compromise which has permitted the value of the pelt to be retained while not exposing the hind quarters to an unnecessary risk of contamination.

5.17 Pelt roll at hide puller

The incidence of pelt roll and fleece contact with the carcass during this stage of ovine dressing is much less than during the Y- cutting procedures. Pelt roll was only observed occasionally at one of the 12 plants visited.

This problem should be solvable at all plants through either work up adjustment with the flanking and shoulder clearance, or by improving the design and/or direction of the hide puller.

5.18 Handling of carcasses

Handling of the carcass by successive workers, especially in areas that have already been contacted, is likely to be how most carcasses are indirectly contaminated on the slaughter floor and in the chillers. Hygienic dressing involves more than attention to careful knife work, hand washing and knife sterilisation. It is inevitably an outcome of a combination of slaughter chain design and the sequential procedures involved in pelt removal and evisceration. Optimal chain design will minimise carcass contamination from the hide, oesophageal and enteric contents on to the carcass while the sequence of tasks and suitability of workstations will also influence the hygienic outcome of the dressing procedures.

Optimal chain design should reduce the number of people handling the carcass with potentially contaminated hands and/or implements. The introduction of automation, for example with trotter removal, has assisted this process. With poor chain design, the ability to work cleanly may be compromised at the onset, and contamination is more likely to occur on a chain where consideration of the likelihood of each step contributing to carcass contamination has not been considered in its design.

A reliance on hand rinsing with warm water to remove microbial contamination is misplaced, as demonstrated by Bell and Hathaway (1996), and any series of tasks carried out by one person that involve hand contact with contaminated surfaces and other parts of the carcass should ideally be avoided.

A US study was carried out by Whyte and others (2002) in which the cleanliness of lamb carcasses dressed under three systems (traditional cradle system versus a hybrid cradle to inverted system) was assessed. The findings indicated that the greatest reductions in microbiological and gross visible

contamination were achieved using techniques that minimised hand contact with the carcass during pelt removal by adoption of inverted dressing procedures, and that hand washing had no significant effect on the level of carcass contamination.

Minimisation of all unavoidable carcass handling from pelting to packaging (such as by using tweezers and hooks where possible) and the cessation of all unnecessary handling, such as where a carcass could be moved or turned by the gambrel rather than by touching the hind leg will reduce microbial contamination of the carcass.

The move towards less handling of the carcass by meat inspection staff (moving from Option 1 to either Option 2 or 3) is part of this minimisation of carcass handling.

5.19 PRE-EVISCERATION CARCASS WASHING

A requirement of the Meat Regulations 1969 was that every sheep carcass shall be effectively washed clean before any opening is made into the abdominal or thoracic cavities (Reg. 94.c). In a study carried out by Biss and Hathaway (1996b) it was found that pre-evisceration washing of carcasses had very little effect on the uncontaminated areas of the carcasses but did reduce the mean APC and *E. coli* at the site of visible contaminants. There was little evidence of redistribution of bacteria to immediately adjacent but visually clean sites. However, the residual levels of both APCs and *E. coli* directly at sites of faecal contamination after washing were still significantly higher than at visually clean sites. Application of HACCP principles to ovine slaughter and dressing suggests that visible faecal material should be removed by trimming or other microbiologically validated means e.g., steam vacuum, whereas pre-evisceration washes can have a practical role in the removal of wool. There was generally a good correlation between APCs and *E. coli* counts at the uncontaminated sites prior to pre-evisceration washing, suggesting that in some situations APCs can act as a useful indicator of both general carcass hygiene and the presence of faecal indicators. This work also indicated that trimming of faecal contamination was preferable to the washing of carcasses, as bacterial counts, although reduced by washing, remain elevated at contaminated sites on the carcasses compared to those found at visually clean sites.

Under the Animal Products Act (1999), carcass washing is no longer a specific requirement and the industry has responded. Over the last two decades, the New Zealand sheep meat industry has significantly reduced the routine use of pre-evisceration washing of carcasses.

In 2019, the only water being applied to the carcass pre-evisceration was at two of the 12 plants visited that used running water over a sparge bar or stainless-steel sheet that had been installed to prevent carcass swing after the changeover. At both plants, the water was applied indirectly to one side of the carcass over the rib cage and below.

5.19.1 International comparison

In Australia, one processor restricted the pre-evisceration wash to handheld spraying of the brisket area only, as a customer requirement for some of their production. No other processors washed the carcass prior to evisceration.

In Argentina, Canada, Chile, Iceland, Ireland, Norway, and the UK there was no washing of the carcass prior to evisceration. In the UK, Hudson and others (1998) conducted a study to evaluate the use of a marker organism for assessing whether hygienic slaughter practices were being followed at red meat abattoirs. The organism, a non-pathogenic strain of *E. coli* K12 that was resistant to nalidixic acid, was detected and counted on a highly specific isolation medium. The carcasses of sheep processed at a

low-throughput abattoir were contaminated with the marker after the fleece had been inoculated at a single site. The authors noted that the contamination was significantly reduced when the operator responsible for flaying had cleaned their hands, arms, and apron before and during the handling of each carcass and used a knife which was sterilised on several occasions. However, the authors also concluded that the subsequent washing of carcasses had little or no effect on the levels of the marker organism.

The US model of ovine dressing employs intensive pre-evisceration washing of the carcass which at one plant was preceded by steam vacuuming of the entire carcass but not trimming.

5.20 IDENTIFICATION OF CONTAMINATION BY COMPANY

5.20.1 New Zealand

Up until a decade or so ago, meat processors took limited responsibility for the identification of contamination and the standard procedure was to rely on the meat inspector to find and detain all visually contaminated carcasses. This practice often led to meat inspectors trimming visible contamination themselves if time permitted to avoid the need to detain carcasses. This practice was helpful in that many carcasses requiring only a minor trim were not detained and this prevented chain stoppages if the detain chains were almost full. However, this meat inspector activity often led to the true prevalence of poor dressing techniques being hidden. At some plants it also led to conflicts between inspection staff and companies when not all inspectors were prepared to trim carcasses or felt that their goodwill was being taken advantage of to cover for poor dressing, or that trimming compromised the time available for inspection.

However, over the last decade or so, the concept of companies taking responsibility for the detection, identification and removal of visible contamination has become an accepted practice. All premises visited had a system to identify those carcasses that have become contaminated and for encouraging those workers that have the opportunity to do so, to remove any visible contamination prior to the carcass reaching the inspection point.

Data from the AsureQuality (AQ) Benchmark database indicates that gross contamination rates for lambs have changed little between 2009 and 2019, averaging around 4-5% for faecal contamination and around 3-3.5% for ‘other contamination’, such as wool, grit and pumice. However, the gross contamination rates for adult sheep have declined, with faecal contamination dropping from around 7% to 5% over the same period, while ‘other contamination’ has dropped from around 5% to 4%.

5.20.2 International comparison

In Australia, the company was expected to have all critical contamination on the carcass identified prior to the carcass reaching the meat inspector. If the contamination was sufficiently extensive to preclude trimming on-line, the company was responsible for detaining those carcasses, trimming them and then clearing the carcasses for return to the chain. In short, the company had taken responsibility for the detection, identification, and removal of faecal contamination.

In Canada, Chile, the EU, Iceland and Norway, the processor relied on inspection staff to detect and identify all contamination remaining on the carcass, although trimmers prior to the inspection station were encouraged, where feasible, to remove any contamination they detect.

In the UK, some establishments selected the carcass inspection station as a Critical Control Point in their HACCP programme and used the inspection carcass contamination location data as feedback.

In the US, all contamination was expected to be removed from the carcass prior to presentation to the meat inspector. However, the carcass meat inspector was still expected to take action if they detected faecal contamination. At one establishment, the chain was stopped and a company trimmer trimmed the contamination from the carcass at the inspection station to the satisfaction of the inspector. At another establishment, any faecal contamination was identified by a paper towel and removed at the next trimming station under the supervision of a meat inspector.

5.20.3 Discussion

New Zealand and Australia have moved much further down the path of devolution of responsibility for detection and identification of faecal contamination from government inspection to processor than many other countries. There is additional oversight by the competent authority in both countries to ensure that the processor has an effective programme to detect and remove the contamination; known as the Zero Faecal Tolerance (ZFT) programme in New Zealand and Meat Hygiene Assessment programme in Australia.

There is one contradiction in this direction of meat inspection reform that has emerged in Australasia. AsureQuality or the Australian Quarantine and Inspection Service inspectors have been redirected to focus more on the identification of defects and abnormalities of food safety significance. Whereas visible contamination is typically considered a 'wholesomeness' issue and is expected to be managed by the operator. However, the emerging food safety risks of the twenty first century are increasingly becoming restricted to enteric bacteria, such as STEC, that are likely to be at higher levels in faecal contamination.

In mitigation of this approach, it is accepted that carcass contamination by enteric organisms more often will occur without gross visible evidence, and that GHP during dressing is now arguably more important in minimising such microbial contamination.

5.21 TRIMMING OF CONTAMINATION PRIOR TO RINGING

The trimming of carcasses between pelt removal and ringing (freeing the anus from the carcass while leaving it attached to the colon) was carried out in eight of the 12 plants visited in 2019 with only four of the trimmers at those plants using tweezers. At those plants where trimming was not carried out, the common salient feature was a lack of a suitable platform prior to the ringing operation. Most of the visible contamination trimmed at these stations was around the hind quarters and abdomen.

Trimming of carcasses between pelt removal and ringing using tweezers should be a routine procedure in all establishments where there is space to do so.

5.22 TRIMMING OF CONTAMINATION BETWEEN RINGING AND CARCASS INSPECTION

The trimming of carcasses between ringing and carcass inspection is carried out to a variable degree between plants.

Of the 12 plants visited in 2019, five had no routine trimming stations, while at another five plants, there was only one trimming station. At the two plants that had two or more trimming stations, one had two and the other had seven.

At three plants there were trimming stations between the ringer and opener and at two of these plants the trimmers used tweezers. At two plants trimmers were stationed between the opener and guttie (operator who removes abdominal cavity contents) and at both plants tweezers were used. At one plant a trimmer using tweezers was stationed between the guttie and pluckie (operator who

removes thoracic cavity contents) while at four plants there were trimmers stationed between the pluckie and the carcass inspector. This variation in trimming stations is summarised in the table below.

Tweezers were used by trimmers between the ringer and the carcass inspector at five plants and at only two of these plants were tweezers used at two stations.

Position of trimming station	Number of plants	Plants where trimmers were using tweezers
Between ringer & opener	3	2
Between opener & guttie	2	2
Between guttie & pluckie	1	1
Between pluckie & inspection	4	2

5.23 TWEEZERS USED BY TRIMMERS

Use of tweezers by trimmers should become routine in New Zealand ovine establishments as an effective means of reducing the passage of contamination between carcasses. Compared to hands, which remain contaminated after rinsing in 44°C water, tweezers can be readily sterilized in 82°C water between carcasses. To make the shift from using hands to tweezers is minimal for the operator and a small one-off cost to the processor.

The use of tweezers is a simple and effective way to reduce unnecessary carcass handling and microbial carcass contamination.

5.23.1 International comparison

The practice of using tweezers for trimming was widespread amongst many of the countries visited.

It was routine practice in premises in Australia, Chile and Norway, in some premises in the UK and US while it was not observed in Argentina, Canada or Iceland.

5.24 RINGING METHOD

In only three of the 12 plants visited in 2019 was the ringing operation carried out with the use of a hook while in the other nine plants, the operator used their finger to lift the anus prior to incising around it.

This is one important area where there are advances to be made, especially in those establishments that are continuing to use Option 1 post-mortem ("hands on") inspection (as there is notable handling of the anal/rump area while palpating lymph nodes). The left hand (i.e., non-knife hand) of the ringer will unavoidably contact the anus during grasping and withdrawing it while ringing with the knife. The left hand is always rinsed after this operation but often the first contact with the next carcass is with the area just below the tail with the left hand.

Reliance on a brief rinse in warm water to remove enteric bacteria from the ringer's hands is misplaced. The use of a hook to carry out the ringing procedure which can then be sterilised in 82 °C water will greatly reduce the likelihood of microbiological carcass contamination.

Compared to the processing of bobby calves in New Zealand, where at all export premises the ringer now uses a hook, this is an area where the ovine industry could greatly improve its risk minimisation with respect to carcass contamination.

5.24.1 International comparison

The use of ringing hooks was routine in Australia, Iceland and some UK plants but at the time of visiting was not being used in Argentina, Canada, Chile, Ireland, Norway or the US.

Routine use of the ringing hook should contribute to a reduced incidence of carcass contamination, especially when the carcass is also repositioned by using the non-knife hand.

5.25 BLADDER REMOVAL

The practice of removing the bladder from the remainder of the bung set used to be carried out in around a quarter of plants in 2009 but was not routinely performed in any of the 12 plants visited in 2019. During removal of the bladder from the bung set, there was occasionally urine spillage over the viscera, especially if the bladder was full.

The least risky procedure to carcass hygiene is to leave the bladder attached to the bung set, which is now routine practice in New Zealand.

5.26 LEAVING BUNG ATTACHED TO GASTRO-INTESTINAL TRACT

This procedure appeared to be standard in most other countries and avoided the possibility of faecal spillage from either the distal colon or severed bung (a word used to describe the anus, distal colon, bladder along with uterus and vagina in non-pregnant female sheep, also called the bung set) into the abdominal cavity, as well as obviating the need for stripping the bung.

The time required to strip (move faecal pellets from the distal colon to below where it will be severed) then sever the bung, and then sterilise the knife prior to continuing the evisceration could be better used in other operations, such as removing the fat curtain and opening the abdominal wall to increase visibility of the rectal cavity for the meat inspector, or removing the tail stub and placing it on the viscera table as a product to be saved. This would have the added benefit of allowing the pelvic cavity to be more effectively viewed for faecal contamination.

Despite the bung being stripped of substantial faecal pellets in the standard operation, there will still be microbiological contamination of the knife blade and any viscera that contact the severed end of the colon.

Where the bung is to be left attached to the colon, it is imperative that the bung is pulled out sufficiently to clear the abdominal wall and laid over the protruding viscera to ensure the anus does not contact the abdominal wall. It is also important that there is no extrusion of rectal contents occurring over the abdominal viscera during the interval between the bung being exteriorised and the abdominal viscera being removed.

In 2009, four of the 35 ovine plants were leaving the bung attached to the colon, while in the 12 plants visited in 2019 this practice was not carried out by any operators.

Removal of the bung is one procedure that could be readily shifted from the evisceration process to the viscera table or green offal department with an associated decrease in risk to carcass hygiene.

5.26.1 International comparison

In Australia, the procedures observed ranged from stripping the colon, severing and removal, to bagging the bung and leaving it attached.

In one premises visited in Canada, the bung was not left attached but removed without stripping.

In Chile, the bung set was left attached to the colon and placed on the viscera table at both premises visited.

In the US, and all four establishments visited in the UK, the bung set was left attached to the colon until after evisceration. This practice was also followed at two of the three plants visited in Iceland while in Norway the one plant that removed the bung set from the colon also used a vacuum device to empty the contents of the bung prior to the inverted evisceration.

5.27 CARCASS MEAT INSPECTION

In 2012, two new methods of ovine carcass inspection (Options 2 and 3) were introduced to sit alongside the one previous method that relied on considerable palpation of the outer and inner carcass surfaces (Option 1). There has also been the introduction of company inspectors by some processors to examine carcasses for diseases and defects that are not related to food safety. This has led to considerable variation between plants in the degree of contact between the meat inspector's hands and parts of the carcass.

At some plants using company inspection to complement that by the official inspector, there is contact of the abdominal walls by both inspectors looking for different diseases and defects. This unintended consequence of meat inspection development has been a retrograde step in terms of carcass hygiene.

Of the 12 plants visited in 2019, three were using company meat inspectors to complement AQ inspectors while the other nine plants used only AQ inspectors. At two of the 12 plants, Option 1 inspection was used for lambs which entailed contact between the meat inspector's hands and the forelegs, abdominal walls, hind legs (popliteal ln), rectal cavity (ischiatic ln), precrural ln, shoulder (prescapular ln), back and neck. In contrast, at the one plant using the Option 3 inspection method, the meat inspector only contacted the abdominal walls.

The Animal Products Notice Ante-Mortem and Post-Mortem Examination of Mammals, Ostriches and Emu Intended for Human Consumption 2015 states that "The post-mortem examiner must conduct post-mortem examination so as to minimise cross-contamination between carcasses and in accordance with the procedures described in the Post-mortem Examination Procedures".

At one plant that used both company and AQ inspectors, the forelegs and abdominal walls of every carcass were handled by both inspectors. This double handling of areas of the carcass likely to be contaminated is an unintended consequence of the introduction of company inspection and one that is unhelpful to improving carcass hygiene.

Given that the forelegs are likely to be a site of microbiological contamination, then those plants using Option 1 and 2 will be at greater risk of more extensive carcass contamination than those using Option 3. Those processors utilising company inspection sometimes actually increased the manual handling of the carcasses as both meat inspectors and company inspectors frequently handled the same parts of the carcass. Reducing the handling of carcasses is an important step in minimising overall microbial contamination, so where possible, inspection tasks should be allocated to increase efficiency and minimise handling regardless of who performs which function.

5.28 CARCASS HANDLING BETWEEN THE Y-CUT AND GRADING

This should be minimised and wherever possible any movement, such as to re-orientate the carcass, should be carried out by using the gambrel or other mechanical means. Routine handling of the carcass by the rectal cavity is not uncommon by those operating the scales, and the absence of hand washing facilities at this station makes cross contamination more likely.

For those operators routinely handling carcasses, facilities for regular hand washing should be made available, especially where the selected ZFT programme option is for all carcasses to be checked.

Of the 12 plants visited in 2019, at only one plant was there no further routine contact with the forelegs after the Y-cut, at 9 plants the forelegs were contacted at two positions, while at the remaining 2 plants the forelegs were contacted at three positions including the company meat inspector, AQ and the ZFT operator (100%) at one of these plants.

The abdominal walls were handled after the Y-cut at either 7 positions (at 2 plants), 8 positions (at 6 plants) or at 9 positions (at 4 plants).

From after carcass inspection to grading and the ZFT check, the abdominal walls were routinely handled at either 3 positions (at 3 plants), 4 positions (at 8 plants) or at 5 positions (at 1 plant).

At 11 plants the grader routinely handled the abdominal wall with other parts of the carcass also being handled including the back (at 9 plants), the hind leg (at 4 plants) and the pelvic cavity (at 3 plants).

Given the opportunity for a contamination pathway between the forelegs and the abdominal wall during carcass inspection, every subsequent contact by trimmers, fat removers, ZFT operators and graders is likely to increase the contamination loading and distribution around and between all carcasses.

Processors are encouraged to implement the use of hooks or tweezers where possible with particular attention being paid to ZFT operators and at the grading station.

5.29 ZERO FAECAL TOLERANCE

This programme was introduced into all US listed plants as an Overseas Market Access Requirement (OMAR). It involves another examination of the carcass prior to it leaving the slaughter floor and it is conducted either before or after the grader. The ZFT checker is required to view the entire carcass, which will necessitate the parting of the abdominal wall flaps to view the abdominal and thoracic cavities and lifting the forequarters, usually by one foreleg and the neck. The ZFT requirement is to either examine every carcass or 10-20 carcasses per run with the proviso that, for the latter option, all carcasses processed since the previous check are re-examined should any faecal matter be discovered.

In essence it represents an additional check for visual faecal contamination to what has already been carried out by meat inspectors and, in some premises, company personnel.

However, especially for the 100% ZFT option, the procedure is very likely to increase the level of microbiological cross contamination between carcasses. Given that the forelegs are likely to be contaminated by the Y-cut procedures, the handling of all carcasses by the forelegs by an operator who occasionally (and sometimes rarely) washes their hands should be considered as unhelpful to improving carcass hygiene.

For this programme, the process of ensuring that no carcass has visible faecal contamination may in effect be contributing to a greater number of carcasses with invisible, microbial contamination.

The dilemma for the operator that wishes to move from 100% ZFT to 10 or 20 carcasses per run, is the considerable extra work involved in rechecking all carcasses processed since the last clear check if this is not able to be completed at a pre-boning inspection (pretrim).

The paradox with respect to carcass hygiene is that in most premises the only operators handling the most likely contaminated part of every carcass (the forelegs) are those checking for visible contamination (the carcass inspectors and ZFT checkers); these operators are probably contributing to the spread of invisible microbial contamination, which is arguably a more significant food safety risk.

5.30 CARCASS INTERVENTIONS

New Zealand does not currently use any routine chemical or hot water microbiological carcass interventions in ovine processing.

5.30.1 International comparison

The only country that utilised chemical interventions during the visits by the author was the US where at three ovine plants, three different systems were used.

One establishment used a double wash system that was standard in the US beef industry whereby carcasses were first passed through a spray cabinet with very hot water (180 to 200 °F) and then through an adjacent spray cabinet with warm lactic acid (5%). These washes occurred just prior to leaving the slaughter floor.

Another establishment did not use very hot water but passed the carcasses through a low pressure/low intensity spray of acetic acid (2 – 2.5%) for 3 to 4 seconds just prior to leaving the slaughter floor.

The third ovine establishment also did not use hot water but instead passed the carcasses through a spray cabinet with chlorine (15 ppm) just prior to leaving the slaughter floor.

5.31 TWO-KNIFE SYSTEM

The two-knife policy was not used by any ovine meat processor in New Zealand during the 2019 review.

5.31.1 International comparison

This practice was widespread throughout meat processing establishments in Australia, Canada, Norway, the US, and the EU. The primary reason for its introduction has been to improve carcass hygiene, and the extra cost was considered worthwhile. The author is unaware of any establishments that have reverted to a single knife policy.

Most establishments used the two-knife policy from sticking to hide removal, although one Canadian beef plant used it from sticking to final carcass trim before the scales. For sheep establishments, it was used either from sticking or brisket patch removal onwards until the hide is removed, although in Norway it was used from sticking to final trim.

One consideration is that the policy requires the use of the dunk type of steriliser which has been modified to allow two knives to be left suspended in the water. The two-knife system would not work with the spray type sterilisers that operate only when knife movement occurs.

One consequence of the introduction of a two-knife system has been several studies investigating the hygienic effectiveness of operating with steriliser water temperature of less than 82 °C. The greatly increased contact time between knife and hot water with two knives (i.e., over 6 to 7 seconds) compared to that obtained with a one-knife policy (around 1 second) should allow for an equivalent degree of "sterilization." Although EU Reg. 853/2004 requires that knives used in meat processing be disinfected by submerging them in 82 °C water, alternative procedures are permitted if the efficacy is proved to be equivalent.

An Australian study (Eustace *et al*., 2007) considering alternative processes for cleaning knives used on the slaughter floor concluded that, after rinsing the knife in hand wash water, using two knives and cleaning them in 60 °C water between alternate carcasses provided a process equivalent to momentary dipping ("sterilizing") in 82 °C water. The potential benefits of using cooler water to clean knives include a reduced risk of operator injury through scalding, reduced water heating costs and reduced condensation and fogging on the slaughter floor. This approach was confirmed by Goulter and others (2008) who studied the effect of differing time and temperature combinations in relation to "sterilizing" knives. The authors emphasised the importance of pre-rinsing knives at 40 °C to improve the performance of subsequent dipping.

A more recent European study (Leps *et al*., 2013) looked at combinations of time and temperature (along with lactic acid and ultrasound) and found that immersion in 70 °C water for 10 seconds provided an equivalent level of disinfection to dipping in 82 °C water.

The introduction of a two-knife policy should provide a hygienic benefit to carcass dressing on its own but could be followed by an equivalence approach to use a reduced hot water temperature. However, it is acknowledged that other advantages of the spray type sterilisers may well deter processors from moving back to dunk sterilisers.

5.32 TREATMENT OF WOOL AS A CONTAMINANT BY INSPECTORS

The treatment of wool by company and inspection staff would appear to be different between New Zealand and the rest of the world. Traditionally in New Zealand a clump of wool with 10 hairs or more is considered a major contaminant that must be identified and removed prior to final inspection of the carcass. For clusters of nine or fewer wool fibres, the company is permitted to allow the final carcass wash to remove them, although this is not always successful especially in the axillae. The number used to decide whether a clump of wool is a significant hazard is somewhat arbitrary and has no relationship with any other measures such as fleece length or dirtiness of the line. The number of fibres is unlikely to have any relationship to their potential for microbiological carcass contamination.

The processing of wet sheep in New Zealand gives some credence to the concept of treating wool as a contaminant that should be removed especially prior to carcass washing and spray chilling.

Clumps of dry, visually clean wool on a carcass, that remained dry through to the pre-trimming station in the cutting room, would be less likely to present a risk to the microbiological status of the carcass, than would wool on carcasses that are washed prior to chilling.

5.32.1 International comparison

In Canada and the US, wool was not regarded as a serious contaminant, but the company was expected to remove any loose wool by using a carcass wash at the conclusion of the slaughtering process.

Other countries, particularly in the EU and Norway, regarded wool as a defect that should be removed at the pre-trimming station in boning rooms prior to the cutting of the carcass, which also acknowledges the reality of small clumps of wool being more easily seen when the carcass surface is thoroughly dry, and trimming of the carcass can be more precise with less collateral wastage of product when the carcass has set.

This approach deserves greater attention from a risk management perspective in New Zealand.

5.33 HAND WASHING BY INSPECTORS

Under IS5, all personnel working on the slaughter floor, including meat inspectors, were required to wash their hands and arms whenever they contact contaminated items or surfaces or otherwise on a regular basis, at the start of work and after every break (Section 5.1.2). The frequency of washing required by meat inspectors where they have not contacted contaminated surfaces was deemed to be every five or six carcasses as a pragmatic compromise. The current Code of Practice 5 does not identify any specific hand-washing frequency, although washing when contaminated is still required by Industry Standard 3 (section 17.3.3).

Studies undertaken by Bell and Hathaway (1996) to determine the hygienic efficacy of hand wash and knife "sterilization" procedures indicated that only moderate reduction of microbiological loading occurs with brief rinsing of hands in warm water. A rinse with warm (44 °C) water removed 90% of the microbial contamination from workers' hands, but rinsed hands especially after contacting fleece, still carried a microbiological load exceeding 4.0 $\log_{10}$ cfu/cm^2.

Some retail clients of New Zealand meat companies have insisted that meat inspectors rinse their hands between each carcass regardless of whether their hands are contaminated or not. However, by ensuring their hands are always wet this practice may well be counterproductive in terms of reducing the microbiological loading on the carcass. The requirement is not for soap, scrubbing, rinsing and thoroughly drying their hands, which is likely to make a difference, but simply to rinse their hands under warm running water. Contact between constantly wet hands and the carcass will make it more likely that bacteria are added to each carcass by the inspector at the point of contact, and below as water runs down the carcass, compared to contact with dry hands.

It is recommended that a scientific evaluation be carried out regarding the merits of this practice with respect to carcass hygiene and whether the practice meets the requirements of the Animal Products Notice: Ante-Mortem and Post-Mortem Examination of Mammals, Ostriches and Emu Intended for Human Consumption 2015 which states "The post-mortem examination must be conducted so as to minimise cross-contamination between carcasses and in accordance with the procedures described in the Post-mortem Examination Procedures".

In 2009, at 10 of the 35 export ovine establishments in New Zealand, meat inspectors were required to rinse their hands after every carcass as a client requirement. In 2019, at the 12 plants visited, meat inspectors rinsed their hands in this manner at two of the premises.

5.34 STERILISATION OF KNIFE AFTER ENTERING BLIND CAVITY

New Zealand regulators have used this precautionary concept and applied it to all cavities including those that do not remain "blind" for long. The rationale behind the concept is that if the operator is unable to ascertain whether or not the cavity that the knife entered contained any material that would have contaminated the knife, they must sterilise the knife after use before it contacts the carcass again.

In IS5, section 5.2.2(b) stated: "*In addition, all equipment shall be additionally sterilised after the following: incision into a blind cavity, e.g., thoracic stick, ringing, brisket opening or pluck removal…. This does not include incision into joints or the spinal column or tongue*." Code of Practice 5 is less prescriptive and states as guidance that "*All equipment should be cleaned and sanitised when contaminated*" and goes on to provide examples of when contamination might occur, which includes incision into a blind cavity.

There appears to be little scientific justification for assuming blind cavities are inherently hazardous to carcass hygiene and the requirement to rinse the knife in hot water after being placed in such a cavity may indeed confer no significant benefit to the consumer.

This concept may be valid with respect to the thoracic cavity after sticking, where the cavity is not cleared of the pluck for some time after the thoracic stick and may therefore be contaminated with either ingesta or bacteria from a pathological process e.g., pneumonia. Sterilising the knife after ringing the bung can also be justified as a precaution against contamination from surface enteric microflora adjacent to the anus or inadvertent incision of the colon and subsequent contamination from the faecal contents, rather than any threat to the safety of the consumer from infectious material being in the rectal/peritoneal cavity.

However, for the abdominal cavity, it will be apparent immediately after opening and evisceration whether the animal was suffering from severe peritonitis, and the knife needed to be sterilised. The abdominal cavity of almost all animals is sterile before opening and the microbiological loading of the hands of the operator opening the abdominal cavity is most likely to be greater than that of the contents of the cavity itself, negating the value of sterilising the knife after the opening cut. The knife should still be sterilised between carcasses as a GHP or if required for export purposes.

It is suggested that for the procedure of opening the abdominal cavity, time spent routinely sterilising the knife after opening the abdominal cavity is unnecessary and could be more usefully spent putting in a transverse incision to expose the pelvic cavity for inspection or clearing the fat from around the pelvic inlet.

5.34.1 International comparison

The author is unaware of any other competent authority that has included this principle in their meat hygiene regulations.

5.35 REMOVAL OF MINOR AND MAJOR CONTAMINATION

'Other contamination' is the term used to describe visible pieces of unwanted material (not of faecal or ingesta origin) that have reached the surface of the carcass during the slaughter and dressing process.

Historically in New Zealand, minor 'other contamination' such as 10 or fewer closely associated strands of wool, and more than a few isolated specks of sand, peat, pumice or dust, were treated by

identification at the carcass inspection stand and retaining for removal on the detain chain. IS5 (section 5.3.20) allowed for carcasses to be passed by inspection staff which had a few (not exceeding 10 closely associated) isolated strands of wool or hair, and/or a few scattered specks of sand, peat, pumice or dust. It was the responsibility of the processor to remove these before the carcass leaves the slaughter board and a final wash or handheld steam vacuum devices may be used for this purpose.

Major 'other contamination' included pieces of skin, more than 10 closely associated strands of wool, more than a few isolated specks of sand, peat, pumice or dust, rail dust, sand, grit, grease, oil, and were treated by identification at the carcass inspection stand and retaining for removal on the detain chain.

Carcasses with 'other contamination' are permitted to be trimmed on the main chain. The distinction between minor and major contamination is arbitrary, unrelated to the food safety significance of the contaminant and is currently only detailed in checks on final product in the boning room or in carcass lot inspections (Code of Practice 9 – Post Slaughter Activity).

Code of Practice 5 (Slaughter and Dressing) is more generic and has expectations that "*any visible contamination (including materials of plant origin) detected on post-mortem examination should be removed by the operator*".

Providing all visible minor or major contamination can be trimmed at chain speed after carcass inspection, the number of strands of wool or specks of sand on the carcass is microbiologically not relevant. What is important is that competent trimming staff can detect and trim all such carcasses and that the company has a programme to verify that the trimming is effective.

5.36 TRIMMING AFTER FINAL INSPECTION – AUSTRALIA

This process step is an integral part of modern ovine dressing in Australia and is a direction that New Zealand processors are encouraged to investigate. The benefits include every carcass receiving scrutiny in specific areas by dedicated trimmers that are provided with stands, lighting and equipment that are designed to facilitate their activity. An ideal arrangement would probably be to have the top, middle, and bottom third of each carcass passing a trimmer on stands with directed lighting that allowed for optimal viewing of each section of the carcass. The not uncommon New Zealand arrangement of requiring trimmers after final inspection on the main chain to bend down and lift forequarters for viewing with inadequate lighting to detect and trim contamination is unlikely to produce the best possible outcome.

The current procedure in New Zealand for removal of non-critical contamination (i.e., not of faecal or ingesta origin) is for the carcass to be detained and all visible contamination to be removed prior to clearance by inspection staff and return to the main chain. However, small clumps of wool are more easily detected after the carcass has dried and often what was barely visible at inspection on the slaughter floor can be more easily detected and removed at pre-trimming after chilling. Instead of relying on carcass washing to remove minor contamination prior to entry to the chiller, there may be a hygienic benefit in leaving some residual minor contamination for removal at pre-trimming, or at load out for whole carcasses.

Importantly, in keeping with the concept of reducing any unnecessary handling, it would be helpful for carcass hygiene to only trim off minor contamination once and carry this out at the processing stage where it is most likely to be detected, that is upon entering the boning room. This re-inspection

by trimming staff would be routine on all carcasses and carried out with effective lighting and facilities. The reduced number of carcasses required to be detained will also have a logistical benefit in that there should be less interruption to the flow of the main chain.

5.37 POST DRESSING CARCASS WASHING AND SPRAY CHILLING

In New Zealand, this practice has been routine for many decades as a means of removing loose wool, especially in the shoulder and axillae regions, along with any grit and dirt from the forelegs and blood that accumulates around the ventral neck after removal of the pluck. Washing the carcass post slaughter was found to reduce the levels of coliforms and *E. coli* on lambs by approximately 0.5 $\log_{10}$ cfu/100 cm^2 in one New Zealand study by Gill and Baker (1998).

In 2009 there were 25 premises in New Zealand that carried out a full carcass wash post dressing, three plants only washed the forequarters, while seven premises did not wash any part of the carcass post dressing.

In 2019, of the 12 premises visited, 10 plants washed the carcass post dressing with less than full coverage carried out at three of them.

5.37.1 International comparison

Australian processors generally either washed the carcass in a specific, but minimal, area or not at all. Some premises used a handheld spray to wash the neck and underside of the forequarters to remove blood drip, either routinely or as a customer requirement for a proportion of the kill. One premises washed the carcasses from the top of the abdominal cavity downwards while another did no carcass washing at all.

In Chile, at one plant there was no washing post dressing while at the other plant, carcasses were washed inside and out by handheld spray. Canada and Iceland also practice post-dressing washing of carcasses. In contrast, in the EU and Norway carcasses were kept dry after dressing in keeping with their practice of avoiding all contact between ovine carcasses and water.

Post dressing carcass washing was standard in the US, where the use of a chemical intervention (such as chlorine, acetic or lactic acid) by all processors and hot water by some were considered essential adjuncts to improving carcass hygiene.

5.37.2 Spray chilling

Spray chilling has been developed as a means of preventing carcass weight loss that occurs during the chilling and drying process. In 2009 in New Zealand, spray chilling was used on all carcasses at six premises, on most carcasses at one establishment, while three more plants intended to introduce the practice. At that time, the other 25 ovine premises did not intend to introduce spray chilling in the near future.

However, in the following decade the practice had become more common and in 2019, at nine of the 12 plants visited, spray chilling was being used.

Given that moisture is a prerequisite for microbial growth, the use of spray chilling and/or carcass washing by processors increases the importance of minimising contamination of the carcass during the slaughter and dressing process.

6 CONTAMINATION PATHWAYS MANAGEMENT (CPM)

The New Zealand meat industry continues to evolve with the advent of new technology, mechanical dressing and a changing workforce to enable the production of a variety of both frozen and chilled meat products. The goal of hygienic dressing must be to transform live animals with extensive internal and external microflora into meat and meat products with minimal surface microflora that will enable them to reach consumers anywhere on the globe and meet their expectations. Any extension of product shelf life is of benefit to the producer.

Understanding how and where on the processing chain the carcass becomes contaminated is the basis of improving hygienic dressing.

CPM is a concept that has been developed by MPI to assist processors to reach the goal of producing the cleanest meat possible from live animals. It has been designed to enable a processor to first determine how contamination is reaching the carcass on the slaughter floor, and then identify the likely pathways of its spread around and between carcasses in their transit from pelt removal to final packaging.

Although microbial contamination of carcasses and meat products during slaughter and dressing may be considered an unavoidable consequence of the physical procedures required to remove the hide and viscera from an animal, the degree and extent of contamination is important. Unless the processor knows where and how the microbial contamination is occurring, any consistent improvement to dressing hygiene will be difficult to achieve.

Specifically, the processor needs to know:

- How is the carcass being initially contaminated?
- What parts of the carcass are being initially contaminated?
- How is contamination being spread around the carcass?
- How is contamination being passed from carcass to carcass?

Gaining an understanding of contamination pathways requires a knowledge of the areas of contamination on and in the live animal prior to slaughter along with careful observation of the processing chain to discover at which steps, and where on the carcass, contamination is occurring and how it may be passed on to subsequent carcasses.

6.1.1 Useful assumptions

- Anyone handling the fleece is likely to have contaminated hands
- Hand rinsing with warm water will not remove all contamination
- Tasks that rely on hand rinsing to counter possible contamination are likely to contribute to carcass contamination.
- Workers will occasionally change their work routine and order of tasks
- Workers will occasionally carry out a function to make up for a task not done by the preceding worker or to help the next worker
- Workers may become tired and/or inattentive towards the end of their shift
- Carcasses do not become sterile post inspection
- Post inspection workers handling every carcass are likely to have contaminated hands and rarely wash them

- Interventions (such as hot water, steam or chemicals applied to the carcass) may reduce contamination but not remove it
- Hygienic dressing is preferable to poor dressing and subsequent anti-microbial interventions

6.1.2 Identification of contamination pathways

The identification of contamination pathways necessitates close observation of all operators from slaughter to the boning room.

During observation, three questions should be considered for each position.

- What is the likelihood of the carcass being contaminated by the operator's action?
- What is the likelihood of the operator's hands becoming contaminated by their actions?
- What is the likelihood of the contaminated carcass being a source of contamination to other carcasses through direct or indirect contact?

Recording

The sequence of actions carried out in all processing steps from arrival to packaging must be recorded. For most processors, this information will already be documented in the job description for each workstation, however the order in which the individual steps are performed at each position is especially important to note and is not always included in the job description.

A detailed description of each position along the chain should be made which includes the sequence of actions and all contacts with the carcass and other objects by both hands. The frequency of hand washing and implement rinsing and/or immersion in sterilising water, and between which steps in the task this occurs should also be recorded.

Methodology

- Observe and record every step from stunning onwards for sufficient time to note all contact between the animal or carcass and each hand, and/or knife of each operator (including fomites or common contact points and other carcasses).
- Look for practices that are likely to occur when operators become tired or behind in their work. These may include contact when reaching further than usual, holding the pelt for extra purchase to lift the carcass, failure to sterilise their knife or rinse their hands.
- Record all contact between carcass, objects and people. Be specific in describing the area(s) of the carcass that are being contacted, such as right stifle joint, left anterior neck rather than hind leg or neck.
- Look for any discrepancies between job description and reality. This may include the direction and position of the opening cut into the pelt, the order of tasks, what happens with the unexpected event e.g., leg dropping off a spreader.
- Record any contact between carcass and operator other than with hands (e.g., wrists, forearms, and elbows) and the frequency of washing of those areas.
- Record the frequency of knife and/or hand rinsing and sequence relative to position steps.
- Record the frequency of hand washing with detergent and warm water.
- Record all positions that make up a rotation group, the frequency of rotation and extent of hand rinsing between changing positions.
- Record the order of sterilisation and sheathing of knives.

- Record any potential transmission of contamination from one hand to the other e.g., by swapping the knife hand.

When all information is gathered and tabulated, the processor should be able to determine at which workstations a particular area of carcass is likely to become contaminated and at which positions further along the chain that contamination is likely to be passed around and between carcasses. All positions where the operator routinely contacts specific parts of each carcass and are therefore likely to assist in the contamination of those parts, can be identified.

Additional information relating to the parts of a carcass that are most contaminated during the slaughter process can be obtained for an individual process by obtaining microbiological counts at various locations on the carcass. This microbiological carcass mapping can be informed by a CPM review but can also provide data to inform subsequent CPM reviews by highlighting the parts of the carcass most likely to be contaminated.

In this manner the contamination pathways can be identified.

Once pathways are known, adjustments can be made to prevent or minimise contamination.

6.1.3 Management of contamination pathways

- Minimise the microbiological load on incoming animals by using all practical methods. This begins with encouraging the supplier to prepare their sheep to provide animals that are clean and short wooled over the opening cut lines which can be processed dry. If the processor considers that production of the cleanest carcasses requires damp wool over the forelegs prior to the Y-cut, then a minimal spray of potable water over just the forelegs prior to the animal being slaughtered could be a solution. It is essential that if water is applied to any animal, the process does not spread contamination between animals.
- Minimise the degree of primary contamination during pelt removal for example having the cleanest Y-cut operation possible followed by mechanical flanking.
- Use hooks and tweezers to reduce the likelihood of primary contamination being transferred around the carcass and to other carcasses by eliminating all unnecessary handling.
- Ensure job rotation groups do not include workers from both hide-on and hide–off workstations.

7 HACCP PROGRAMME

The steps that the sheep processing industry are advised to follow in developing their HACCP plan are outlined by the Codex 2003 advice. They are:

Central to the control of food hazards through the use of HACCP, a food business operator (FBO) should:

- identify any steps in their operations which are critical to the safety of food.
- implement effective control procedures at those steps.
- monitor control procedures to ensure their continuing effectiveness, and
- review control procedures periodically, and whenever the operations change.

The FBO will have previously documented Good Operating Practice (GOP) in relevant supporting systems (also known as prerequisite programmes, GHP) before applying HACCP principles to the process.

Although explicit directions are given to FBOs as to how these critical steps are to be controlled, the identification of such steps is left to industry with no specific guidance.

In New Zealand, these supporting systems must comply with all relevant regulatory requirements, particularly the current versions of the Animal Product Regulations, the Animal Products Notice (Specifications for Products Intended for Human Consumption) and the Animal Products Notice (Specifications for Products Intended for Animal Consumption).

Each documented supporting system should provide information on authorities and responsibilities, procedures (including control, monitoring, corrective action, and operator verification procedures), and requirements for record keeping.

The 2008 NZFSA document that described hazard analysis and CCP Determination was “Generic RMP [Risk Management Programme] Models for the Slaughter and Dressing of Farmed Mammals”. The document described a CCP as a step at which control can be applied and is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level. The control measure at the step must be essential to food safety as defined by a regulatory limit or an operator defined food safety limit (i.e., no CCP if there is no defined limit). A critical limit, which is measurable and can be monitored on an ongoing basis, must be established for the CCP.

Within the CCP Summary (2.8) the document stated that if a CCP was not identified for the slaughter and dressing of livestock, the control of hazards at key steps is expected to be adequately addressed by GOP.

If the use of HACCP by processors is viewed as simply a regulatory requirement that must be met, in that only one CCP is sufficient for their plan to meet the US OMAR requirements, then it will do little to improve their understanding of how their product is becoming contaminated. Furthermore, if every step along the processing chain in which contamination was suspected to occur was deemed a CCP, the monitoring and follow up for each such CCP would place unnecessary and unwarranted obligations upon the company.

The monitoring of CCPs on the slaughter floor in real time is typically only carried out by observation, usually of faecal matter, when with respect to carcass contamination in the modern era of meat processing, it is likely that invisible contamination is the major source of unwanted organisms on the final product

CPM recognises that invisible (microbiological) contamination provides a greater risk to the consumer than observable contamination and entails detailed observation and recording of all slaughter and dressing procedures to identify pathways by which carcass contamination may occur.

The intention of CPM is to enable premises to reduce the likelihood of invisible carcass contamination occurring rather than reliance on carcass inspection, interventions, HACCP and ZFT programmes to remove it.

8 DISCUSSION

The focus for improving carcass hygiene in the 21st century has shifted from the identification and removal of grossly visible contamination to the prevention and minimisation of any carcass microbiological contamination which may affect the consumer. In short, this involves a transition from the visible to the invisible. Hygienic dressing refers to the production of a carcass from an entire animal that has the lowest possible microbiological surface population. Contamination pathways refers to the routes that bacteria have taken to reach various parts of the carcass.

An understanding of the causes of microbiological carcass contamination involves the realisation that carcass contamination is as much (if not more) affected by contact with the pelt as it is from faecal spread. Unwanted organisms arrive at the processing plant with the animals as bacteria in the gastro-intestinal tract (GIT) and on the pelt. The bacteria may be further distributed between animals by certain washing practices, such as swim washes, and the transportation/yarding processes prior to presentation for slaughter. During slaughter and dressing, the removal of the GIT from the carcass presents a risk of contamination at either end of the tract; over many decades in New Zealand these processes have been refined to minimise the likelihood of contamination from the GIT through careful isolation and occlusion of the oesophagus along with hygienic ringing of the anus.

The other source of carcass contamination is from the pelt during its removal from the carcass. The opening lines are from the upper neck to the inguinal region and from the brisket to knuckle on the forelegs. Reflection of the pelt along the opening lines and contact between contaminated hands and the carcass is likely to result in contamination of the underlying carcass which can be further distributed around and between carcasses along the chain.

Visible faecal contamination has received considerably more attention over the years than microbiological (invisible) contamination from the pelt. The industry has reached a plateau of around 5% of ovine carcasses being visibly contaminated at final carcass inspection over the last two decades, but the remaining 95% of the daily kill is still being contaminated to a variable degree, unseen by inspection staff, by bacteria commonly found on the pelt.

This is where improvements in hygienic dressing can be made.

Historically the processing industry in New Zealand has greatly improved techniques for preventing contamination from either end of the GIT reaching the carcass and continues to rely on observation and removal of faecal deposits to remove contamination. There is still considerable variation within the industry between those processors following best practice and the rest. The same degree of scrutiny has not been applied to contamination from the pelt, which is mostly invisible and not detected by organoleptic examination, and that needs to change. With recent improvements in testing and identifying unwanted organisms, the surface microflora on meat is likely to come under greater scrutiny in the future, which in turn will necessitate greater attention being paid to invisible contamination. The recent increased attention being paid to shiga-toxin producing *E.coli* (STEC) in beef and veal should serve as a warning to all meat processors.

Overall, positive changes from a hygienic dressing perspective were noted at many NZ premises in 2019 when compared to the observations made in 2009. During the overseas visits a large variation in practices was seen, with some procedures likely to result in poorer outcomes for carcass hygiene, while others were considered likely to result in improved microbiological outcomes. While these overseas premises may have changed their processes since the visits, the observed practices still

highlight areas that the NZ processing industry could consider to further improve the microbiological contamination levels on carcasses.

8.1.1 Presentation

Treatment and presentation of the animal prior to slaughter is now accepted as having an important influence on the final carcass hygiene status.

New Zealand is unique amongst sheep meat exporting nations in washing all sheep and lambs prior to slaughter with a range of methods being used by different processors, from belly washing to full immersion. The background to the introduction of 100% ovine washing has been detailed earlier in this document and since those times, many changes have happened to New Zealand's pastoral and processing industries. Inverted dressing has reduced the importance of the cleanliness of the hindquarters in that many processors now remove the pelt from the animal without opening the hind legs, or even, in the case of a few processors, removing the anal scallop. This development on the slaughter floor has similarly reduced the importance of the cleanliness of the hindquarters of the live animal, once the main focus for the farmer in crutching all sheep prior to slaughter. In the 1960s, wool was a valuable product and the predominant sheep breed in the country was the Romney, with woolly socks and bellies. Over 70 years later, wool is much reduced in value and apart from fine woolled breeds, many sheep breeds in New Zealand now exhibit much shorter belly and inside leg wool. Some breeds have no wool in these areas. This development has encouraged progressive processors to use a range of actions that reflect the microbiological risk of each line of sheep, instead of treating all lines as equally risky.

Swim washing is still used at some New Zealand ovine establishments, with up to several thousand animals being swum through one body of water prior to the wash being emptied and cleaned at the end of the day or shift. At these plants, there will be an increased propensity for cross contamination from the fleece to the carcass to occur that results from immersing animals in water contaminated with enteric organisms and then processing these animals before the fleece is dry. Paying close attention to the cleanliness of the slaughter facilities, the workers and their equipment, while presenting sheep for slaughter that have had their microbiological loading increased in the lairages would appear to be counterproductive and contradictory.

The goal of developing the cleanest pelt opening possible is paramount as these actions influence the initial microbiological loading onto the carcass, and the magnitude of microbial contamination spread further along the chain. The loading along the forelegs and belly can be reduced by preparation of the opening lines before the animals leave the farm and in the lairages. Visual cleanliness of the live animal does not necessarily indicate low microbiological populations. Optimal dressing hygiene would be facilitated by processors presenting the slaughter floor with animals that have short wool over the opening lines (less than 10 mm if possible) that is clean and dry.

The means by which sheep are presented in an ideal state for hygienic processing are varied. On the farm, if lambs or sheep have woolly legs and bellies, the farmer should be encouraged to remove the wool from along the opening lines before sending to slaughter, along with emptying out the animals prior to loading onto the truck.

If the Y-cutter is presented with an animal that has short dry wool over the opening cut, there will most likely be reduced transmission of microorganisms from the pelt to the carcass. Thus, if sheep have been washed in the lairages, even with short wool over their bellies and legs, they will need a sufficient interval between washing and slaughter that allows for drying. In summer this may be a

matter of hours while in winter it may take significantly longer, which is a constraint to the supply chain.

Some processors have introduced shearing of the opening lines on the chain, along with practical and effective means of removing the loose wool from the legs and bellies. These developments along with processing selected lines without any washing show the most promise in regard to improvements in hygienic dressing.

8.1.2 Pelt removal

The method of opening the forelegs currently widespread in NZ (using the flat blade) may not be as hygienic as the scallop method that is widely used in other countries. When the legger opens up the foreleg with a flattish blade during a spear cut, the pelt will retract and frequently roll over on one side and thus contact the exposed carcass. This will occur irrespective of wool length. With the scallop removal technique, provided there is no lateral sawing movement as the blade travels from the axilla to the foot, there is no undercutting of the pelt on one side (as currently happens with the spear cut) and the only areas exposed to microorganisms are immediately under the parallel incision lines. The scallop method was assessed against the standard opening technique in one six-week trial in New Zealand and found to be marginally cleaner which demonstrates the need for more extensive assessment.

Once the forelegs and brisket have been cleared of pelt, the abdominal midline is the next area of the carcass to be exposed. After the initial midline spear cut, that should be made with the blade at right angles to the pelt, the most hygienic method to clear the flanks is by use of a flanking thumb tool that can be used to clear one side from the inguinal region to the brisket, sterilised and then used to clear the other side.

Manual flanking is predisposed to contaminate the abdominal wall on either side of the midline opening, and this contamination will be increased when one worker is punching the flank on both sides of one carcass, as both hands will remain contaminated throughout the shift. The use of water by the flanker to help push his hand between pelt and carcass is also likely to increase the transfer of contamination from his hand to the abdominal wall.

8.1.3 Trimming

Removal of visible contamination from the carcass at any point in the process is likely to be beneficial with respect to microbiological contamination of the carcass. Minimising the handling of the carcass by workers hands, that are not easily cleaned and dried on the slaughter floor, is therefore likely to be beneficial. Where contamination is removed by trimming, the material being discarded should be held by tweezers where possible as these are easy to sterilise. This approach would also reinforce the concept of minimising carcass handling by workers.

8.1.4 Ringing

The processing step that involves freeing the anus and rectum from its attachment to the rectal cavity, known as ringing, carries a risk to the carcass during dressing in that the anus harbours enteric organisms. The traditional method involves grasping the anus with one finger, applying upward pressure while making three to four stab incisions around the anus to free it from attachments, before releasing the anus and letting it drop back into the rectal cavity. Occasionally the same hand used to hold the anus would contact the hind leg, such as to turn the carcass if the ringer continued to open up the abdominal cavity. With insufficient time to do more than rinse the left hand under

warm water between carcasses, this hand is likely to transfer contamination to any part of the carcass it contacts.

Unlike bobby calf processing, where use of a ringing hook is now standard throughout the country, use of the ringing hook is not routine with most ovine plants continuing to use manual ringing.

Use of a ringing hook is a simple, inexpensive change that could be introduced by every processor wishing to improve their hygienic dressing.

8.1.5 Post-mortem inspection

New Zealand has led the world in meat inspection reform and refined the traditional organoleptic method of ovine post-mortem examination which relied on observation and palpation. Examination activities where the food safety risk of the condition being sought was exceeded by the risk of contamination of the product by manual contact were modified or discontinued. The changes meant that examination for disease and defects could be undertaken in a manner that reduced the likelihood of carcass contamination. The industry was presented with three options, from Option 1 being the status quo and Options 2 & 3 involving much less contact between the examiner and the carcass.

In 2019, only a small number of processors have moved to Option 3 for all ovine classes while many have remained on Option 1.

The introduction of company inspection has inadvertently increased the frequency of contact between examiners and the carcass at some premises, especially of the abdominal walls, as the thoracic cavity is examined by both inspectors. Of the 12 plants visited in 2019, only one plant used Option 3 for lambs with the only contact between the examiner and the carcass occurring on the abdominal wall. In contrast at other plants, with company inspectors as well as those from AQ, examiners palpated both the external and internal (abdominal and thoracic cavities) surfaces of every carcass.

Although the NZ government has enabled all processors to greatly reduce the amount of carcass handling by inspection personnel should they wish, many have chosen not to take the opportunity to move towards the most hygienic method of carcass inspection, Option 3.

For those processors who wish their examiners to continue to handle the carcass, the use of hooks or other mechanical methods to contact the forelegs and abdominal walls is an option that should be seriously considered.

One practice that has been introduced to several NZ ovine premises is a customer requirement for all carcass examiners to rinse their hands between of every carcass. In practice, especially at high chain speed plants, this is likely to ensure that the inspector's hands are close to dripping wet as they contact each new carcass. This practice is unlikely to assist in the reduction of contamination spread around and between carcasses.

8.1.6 Zero Faecal Tolerance

There are two variations of the ZFT programme that can be used to check carcasses for visible faecal contamination with the first checking 10-20 carcasses per run, while the second involves checking all carcasses.

In relation to further distribution of contamination, contact of every carcass by one person handling the abdominal walls and foreleg is likely to distribute any contamination on these areas to many

carcasses. It is mandatory to have such a programme for US-listed plants, but the associated handling practices, unless a hook is used, would indicate that the first option (10-20 carcasses per run) is less hygienically problematic than the second method (100% of carcasses checked).

8.1.7 Carcass Separation

Once carcasses have been passed by the carcass inspector, they are not required to be separated. At some plants, carcasses regularly contact each other as they pass through the stations relating to trimming, fat removal, ZFT checking and grading. Given that many of the forelegs and abdominal walls are likely to be contaminated by this stage of the processing, any unavoidable stacking of carcasses that occurs should ideally be such that the carcasses are aligned and that the forelegs of one do not contact the neck and shoulders of the adjacent carcass.

Where possible, the transit from inspection station to grading station should involve the minimum of handling and cross contamination possible. The use of hooks will facilitate this.

8.1.8 Grading

Practices that should be avoided at the grading station include pulling each carcass forward by the rectal cavity and pushing it away by the hind legs. Graders would ideally move the carcasses by the gambrel, or by hook where possible, and refrain from handling each carcass. If this practice continues throughout the processing period, the touch screen and other contact areas around the station will be a source of microbiological contamination for all subsequent carcasses.

8.1.9 Monitoring of processing

Ideally, any processors of edible product should understand if, how, and where their product is becoming contaminated. Given that production of edible ovine product entails sequential activity by many participants who may not always follow the requirements necessary to produce microbiologically acceptable meat and meat products, it is vital that supervisory staff have good knowledge of the contamination pathways on their slaughter floor.

Microbiological data collected from carcasses on the slaughter floor, post inspection, does not indicate whether that part of the carcass sampled was contaminated directly from fleece or GIT contents, or indirectly.

There are two broad categories of process monitoring used in the NZ meat industry:

1) Visual monitoring

This is carried out by slaughter floor supervisors who, amongst many other tasks, are required to ensure that all workers are following their job descriptions with respect to GHP. Every US listed plant will have a HACCP programme that must be adhered to, however almost all processors now monitor just one critical control point that usually involves a visual appraisal of carcasses each run, with most checking for faecal/ingesta contamination as an indicator of lapses in hygienic dressing.

This method of process monitoring will not reflect the level of invisible contamination that is likely to be occurring over and around the carcass on the slaughter floor, nor indicate the pathways that such contamination is being disseminated by.

2) Microbiological monitoring

The microbiological monitoring of ovines in NZ is covered by the NMD programme. Ovine carcasses are subjected to the least microbiological monitoring of any slaughtered species in NZ, with only APC testing but not for generic *E. coli*. There is also no requirement for any testing of post chill carcass, primal cuts or bulk meat as for beef and bobby veal.

Five carcasses are sampled for each processing week, with the selected carcasses often removed to the detain rail for swabbing after passing inspection. The sample site is along the forequarter opening Y-cut centred on the anterior aspect of the humero-radial (elbow) joint close to the brachial vein. The APC results will reflect the degree of contamination that is occurring during the Y-cut operation and any further contamination of the forelegs that may occur between the Y-cut and the final carcass inspection.

Process monitoring using the NMD will not reflect the degree of contamination that has occurred around and between carcasses on the slaughter floor, apart from what has occurred on the forelegs.

Thus, the typical monitoring practices for ovine slaughter and dressing currently employed will only give the processor information as to the degree of contamination of the forelegs, and visible faecal contamination of the carcass. It will provide no information as to how and where contamination may be spreading around and between carcasses. Currently, most processors do not know how their carcasses are being contaminated on the slaughter floor.

Additional microbiological monitoring of carcasses that identified the likely areas of greatest contamination for a premises-specific slaughter and dressing process would greatly inform CPM assessments and is therefore highly recommended. Initial (and ongoing) carcass mapping could be informed by microbial testing of multiple carcass sites alone, or by newer technologies such as chlorophyl detection, or by performing a CPM review to identify likely areas of high microbial contamination.

8.1.10 Contamination pathway management

This concept reflects the need for processors to understand how their product is being contaminated by discovering what the contamination pathways are, so that they can then take action to interrupt or minimise them. The methodology involves close observation of every position on the slaughter floor and recording every carcass contact and activity by each worker as well as the movement of workers between positions during the slaughter shift. By noting every part of the carcass that is contacted along the chain, the pathways that contamination take from source to specific parts of the carcass can be discovered.

Without this knowledge, processors will find it difficult to improve the hygienic status of their product. Interruption is more effective than intervention and smart dressing is about knowing where the risks to carcass contamination are and managing them.

9 CONCLUSIONS

Observational studies of the slaughter processes at all ovine export slaughter premises in New Zealand conducted in 2009 and repeated at twelve premises in 2019 were complemented by observational studies at 30 ovine slaughter premises in nine different countries between 2007 and 2014.

Differences in processes that were considered likely to significantly impact on the microbiological contamination transferred from the pelt or gastro-intestinal tract to the carcass were assessed for their applicability to slaughter processes in New Zealand, resulting in recommendations for opportunities for improvement in the New Zealand setting.

Recommendations for improvement

Opportunities for improvement in minimising the transfer of microbiological contamination from the pelt/fleece to the carcass in New Zealand include:

1. Pre-slaughter washing should not be routinely practiced
2. Minimising contamination by changing the opening Y-cut technique
3. Minimising carcass contact with contaminated hands
4. Use 'Option 3' ("hands off") carcass inspection to reduce routine carcass handling
5. Using premises-specific carcass microbiological mapping to determine the most contaminated parts of the carcass, thereby facilitating targeted, meaningful interventions aimed at reducing overall microbial contamination.
6. Use of the Contamination Pathway Management tool to evaluate the slaughter process

Notwithstanding these recommendations, best hygienic practice in a particular processing setting will need to consider many factors including practicality, cost, consequential impacts, and the final outcome sought in terms of an acceptable level of carcass contamination. Given these inputs, there is no "one size fits all" template for primary processing of all types and regional sources of sheep carcasses under New Zealand conditions.

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