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C3 - Management of scientific committees II; scientific co-operation and networks

Opinion of the Scientific Committee on Measures relating to Veterinary Public Health

on

Ovine Gas De-pelting

(adopted on 14-15 February 2001)

Acknowledgements

This report of the Scientific Committee on Veterinary Measures relating to Public Health is substantially based on the work of a working group of the Committee.

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Contents

1. TERMS OF REFERENCE

The Scientific Committee on Veterinary Measures relating to Public Health (SCVPH) is requested to assess the risks and the safety of ovine gas de-pelting from a consumer health point of view.

In particular, the Committee is asked to assess whether the process is likely to give rise to additional microbiological risks and to identify the critical points in the gas de-pelting technique.

2. BACKGROUND

Council Directive 64/433/EEC prohibits, in principle, inflation to be used a technical aid during the slaughter process. Only inflation of an organ may be authorised under certain conditions for ritual purposes provided that the inflated organ is excluded for human consumption. Since the last amendment of the Directive a further derogation has been introduced in meat hygiene provisions (Annex I N° 33: "Mechanical insufflation for the flaying of lambs and kids of a live weight of less than 15 kg may be approved by the competent authorities in compliance with the hygiene requirements."

Further possibilities for derogation are not provided for at present. At a meeting of the informal Joint Management Committee, the New Zealand authorities transmitted information on gas de-pelting trials conducted at ovine slaughter lines and considering the satisfying results they would like to authorise this carcass dressing technology in approved slaughterhouses.

3. INTRODUCTION

3.1. Sheep lamb and goat slaughtering in the EU

Slaughter of ovines-and of caprines is a very significant part of overall meat production in several EU countries. When considering the overall volume of ovine-caprine slaughtering in the EU, it is clear that lambs represent the largest volume category, while adult sheep and goats represent a much smaller proportions (see table 1; data provided by Eurostat). The largest numbers of ovines are slaughtered in the UK and Spain (each: >19 millions/year), followed by Italy, Greece and France (each: >7 millions/year). The largest numbers of caprines are slaughtered in Greece (>4 millions/year), followed by Spain (approx. 2 millions/year).

Table 1 Statistic on ovine-caprine slaughtered in the EU

Countries (1999 year)	Sheep		Goat (heads)
	Lambs (heads)	Other (heads)	
European Union	60,180,700	9,582,500	8,250,200
Belgium	109,900	101,600	2,800
Denmark	54,200	10,000	0,0
Germany	0,0	2,187,100	17,300
Greece	6,391,200	978,200	4,552,300
Spain	18,842,100	619,400	1,869,500
France	6,512,000	782,500	1,082,000
Ireland	4,373,600	32,900	0,0
Italy	5,329,900	206,000	423,800
Luxembourg	0,0	0,0	0,0
Netherlands	543,900	115,400	46,500
Austria	0,0	300,000	57,000
Portugal	994,300	74,000	192,500
Finland	39,100	5,800	300
Sweden	162,700	27,900	400
United Kingdom	16,827,800	2,288,000	5,800

The production of sheep and lamb meat is a significant part of economy of several EU countries, as well as an important issue of the EU trade. Commercialisation of sheep-lamb meat production resulted in significant changes of this technology over time. Traditional "cradle" systems were based on a solo butcher conducting all operations involved with slaughter and dressing of animals. In order to increase the productivity, this has been replaced by continuous line systems in which every animal is handled, many times, by a succession of operatives. It was expected that hygienic status of the carcasses would be improved with modern line systems. Handling of carcasses potentially can result in detrimental effects on their hygienic status and any increase in handling will result in a lowering of the hygiene of the carcase. Consequently, in modern times, any technologies used in ovine slaughter and dressing must not be considered only from a commercial perspective, but must be analysed also from the aspect of carcass hygiene. De-pelting technique has been identified as the key operation during dressing i.e. the most critical for contamination of ovine carcasses by operatives. To reduce carcass contamination from the alternate handling of fleece and carcass, as well as to reduce processing costs, mechanised dressing systems for ovines were developed (Nottingham *et al.,* 1974). In principle, automated dressing, such as the mechanised inverted system should result in a better hygiene via reducing fleece-hand carcass contacts, (Longdell, 1992). However, there are reports that automated dressing may result in redistribution rather than an overall reduction of contamination (Whelehan *et al.,* 1986).

3.2. Sheep and lamb de-pelting systems

Currently there are three main dressing systems are used: a) "cradle" pelting system normally used only in small abattoirs, b) conventional de-pelting line system, and c) inverted de-pelting line system. The latter two systems are used in medium and large commercial sheep abattoirs. Gas de-pelting is used for both conventional (e.g. Italy) and inverted (e.g. New Zealand) systems. A diagram (diagram1) explaining a flowchart system of the conventional de-pelting and inverted de-pelting line systems (Bell and Hathaway, 1996) is showed below.

3.2.1. "Cradle" de-pelting system

In small abattoirs with a single slaughterman undertaking all the pelting operations, there is frequent changing of tasks from hand to hand. For example, it is common for the right hand to be holding the pelt while the left hand punches down the right flank of the carcass. The left hand then holds the pelt while the now (unless washed) highly contaminated right hand punches the left flank of the carcass. Frequently small multi-species abattoirs have washing facilities fixed to the wall and inevitably these will not be suitably positioned for all operations on all species. Usually, it is not practical for the operator to clean his hands frequently during the pelting operation so cross-contamination, especially during "punching", a process where the hand is pushed between the pelt and the carcass to free the pelt, is likely to be high. Heavy contamination of lamb carcasses during cradle dressing can occur during the initial stages of pelt removal primarily through the pelt either "tucking under" or from the dirty fleece hanging over the edge of the pelt onto the carcass. The problem is exacerbated during the winter months and especially so if the sheep have fed on root crops

3.2.2. Conventional de-pelting line system

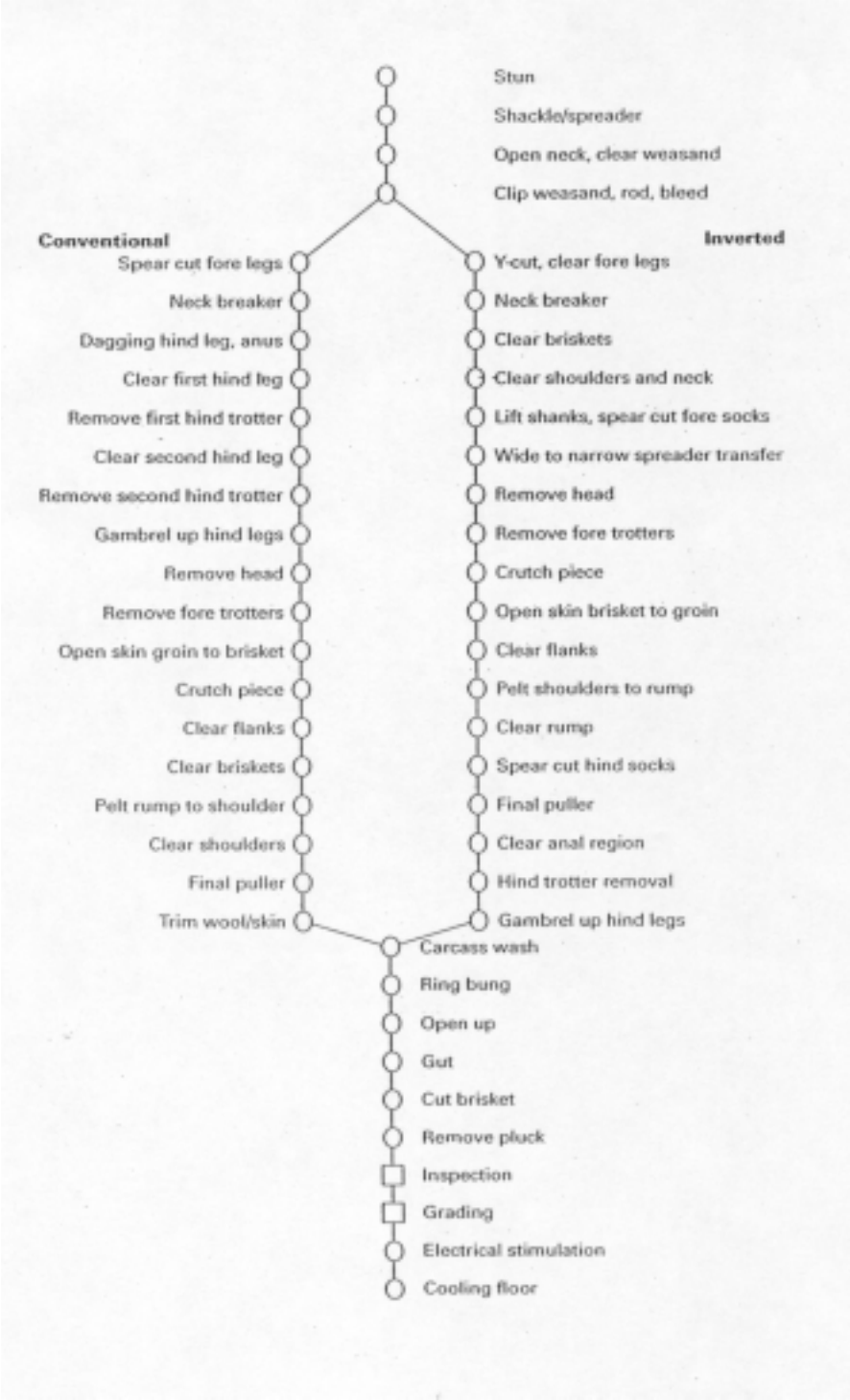
When using this system, the lamb is suspended initially by the hindlegs. Most problems of carcass contamination occur when making the incision lines on the carcass when the pelt is first cut through, as well as with inrolling of the fleece. The pelt is freed manually from hind-quarters and removed to the level of the shoulders by a combination of "punching out" and pulling downwards from tail to head. The skinning of the forequarters can be completed by this downwards pull while the animal is suspended by the hindlegs only. Alternatively, the forelegs can be lifted and hung on a rail running parallel to that suspending the hind-feet, and the skinning of the forequarters can be completed by a horizontal pull. (Gracey *et al.*, 1999). The microbiological profile of operators' hands after dressing procedures that necessitate direct contact with the fleece is similar to that of the fleece itself, so the contact between the carcass and the unrinsed operators' hands may introduce considerable contamination (Bell and Hathaway, 1996). Obviously, hand washing is one crucial factor determining microbial loads of de-pelted carcass. When considering distribution of microbial contamination on conventionally de-pelted carcasses, some authors found the highest bacterial counts on peri-anal area, hind hock and flap, followed by foreleg (Bell and Hathaway, 1996), while others found no great difference in the levels of contamination between hindquarter and shoulder regions of lambs

suspended only by the hindlegs during skinning (Cenci Goga *et al.*, 1996; Trevisani *et al.*, 1996).

3.2.3. Inverted de-pelting line system

In many sheep slaughterhouses, the conventional de-pelting system has been replaced with so-called inverted dressing system (Longdell, 1992). The lamb is suspended initially by the forelegs, the pelt is loosened from around the shoulders and partially freed from hindquarters. Subsequently, the pelt is removed by a mechanical puller from head to tail. This system is considered as generally more hygienic than traditional system (Longdell, 1992; Bell and Hathaway, 1996). The main improvement is based on the fact that de-pelting operation starts at the cleaner end of the carcass, and the pelt is moved downwards towards the rear, more contaminated, end. However, the distribution of contamination on the carcass differs between conventional and inverted de-pelting systems. The area of highest carcass contamination with inverted de-pelting is the forequarter (particularly brisket) and it is associated with opening cuts in the brisket region and subsequent fleece rollback (Bell and Hathaway, 1996). With the conventional dressing in the same study, however, the authors found that the association between high contamination and opening cuts about the hind legs was considerably less obvious. On the basis of high contamination levels on flap observed with both conventional and inverted dressing systems, which is probably due to fleece rollback following opening medial cut (crutch-brisket or brisket-crutch), Bell and Hathaway (1996) suggest that flap is a useful sampling site for routine monitoring of dressing hygiene.

Diagram 1 Conventional and inverted line systems (Bell and Hathaway, 1996)



3.2.4. Gas de-pelting system

The use of air inflation to separate the pelt from the carcass is of great interest as a means of reducing skin damage and labour/time-consuming. It is intended to aid the flaying of the fleece. However, until few decades ago the simplest way of providing inflating air was by mouth, but the inflation of air by mouth was generally prohibited by EU regulations, largely based on a concern of spreading of tuberculosis. The use of mechanically compressed

air offered an alternative means of pelt removal in the commercial slaughter lines. Furthermore, results by Italian researchers (Cenci Goga *et al.*, 1996; Trevisani *et al.*, 1996; Severini *et al.*, 2000) indicated that using mechanical air inflation might not increase carcass surface contamination.

At present, de-pelting assisted by mechanical inflation of compressed air is used in some Member States only for lambs and kids under 15 kg live weight, due to the restriction imposed in the EU from the Directive, and mainly in industrial slaughter lines. However, in the past in some EU countries air inflation had been used also for sheep and goats.

In New Zealand gas inflation is permitted for sheep and lambs for some markets, excluding EU.

There are reports that gas inflation can be used to remove hide in ostrich as this reduces labour and gives more chance to obtain high quality skin. (e.g. USA, Australia) (Morris *et al.*, 1995; Jones *et al.*, 1995).

3.2.5. Sequence of operations in ovine de-pelting and incorporation of gas inflation after stunning and bleeding

Table 2 Sequence of operations in ovine de-pelting and incorporation of gas inflation after stunning and bleeding

Inverted de-pelting with use of gas food grades (CO_2) inflation in New Zealand*	**Conventional de-pelting with use of filtered air inflation in Italy****
Cut away skin just above the tail stump and insert the needle	Remove fore feet
Inflate gas (preferred: pressure 700 kPa for 8 sec)	Insert the needle under the skin of one foreleg
Y-cut, clear fore legs	Inflate filtered air (pressure around 900 kPa for 10-15 sec)
Neck breaker	Opening cuts on hind legs
Clear shoulders and neck	Remove hind trotters
Lift shanks, spear cut fore socks	Hang by hind legs
Wide to narrow spreader transfer	Pelt by pulling downwards to head without any other opening cuts
Remove head	
Further process see diagram 1	***

* Adapted from Bell and Hathaway (1996) and Bell and Lovatt (1999);
** Adapted from Trevisani *et al.* (1996);
*** No literature data available for further process.

4. POTENTIAL RISKS OF MICROBIOLOGICAL CARCASS CONTAMINATION DURING DE-PELTING INCLUDING GAS INFLATION

4.1. Fleece soiling

Although the fleece and viscera are both reservoirs of pathogens and spoilage organisms, contamination from digestive tract (rupture, leakage) is considered as relatively rare and less significant in comparison with contamination from fleece (Gerrand, 1975). For these reasons, it is clear that excessively dirty livestock put the whole hygienic operation of the slaughterhall at risk. Therefore, carcass contamination is primarily, directly or indirectly, related to the hygienic status of the fleece (Empey and Scott, 1939; Gerrand, 1975, Gustvson and Borch, 1989).The fleece of sheep become soiled primarily on the abdomen and on the legs, principally with vegetation, mud and faecal material (Newton *et al.*, 1978). Many factors can affect the degree of soiling including climate conditions, transport conditions, the time spent in lairage, lairage design and practices, as well as the length of fleece (Patterson, 1968; McGrath and Patterson, 1969; Biss and Hathaway, 1995a; Hadley *et al.*, 1997).

4.2. Transfer of contamination from fleece to carcass associated with traditional pelting

4.2.1. Direct transfer

Direct transfer of contamination from fleece onto the carcass will occur when making opening cuts through skin and by the fleece inrolling so that the wool is in contact with the surface of the carcase.

4.2.2. Indirect transfer

Indirect transfer of contamination from fleece onto the carcass include from alternate touching of fleece and the carcass with hands during pelting. Also, contaminated arms during "punching" and contaminated knives used to disconnect pelt from subcutaneous tissues during pulling the pelt can be a vectors for transfer of the contamination. In addition, airborne organisms may be carried on solid particles of (e.g. dust), be present within droplets formed by the atomisation of liquids by spraying and splashing water, or as isolated cells resulting from evaporation of water from droplets (Sullivan, 1979).

4.3. Additional factors potentially associated with gas inflation

4.3.1. Needle used for inflation

Contamination from fleece could be transferred onto the carcass via insertion of needle through the skin. Needle can be contaminated either from the fleece of the same animal or from other animals previously inflated with the same needle (cross contamination).

4.3.2. Site of needle insertion

If, during insertion, the needle carries contamination from the skin at the insertion site to the subcutaneous tissue, then the level of the subcutaneous contamination will be determined by the level of contamination of the fleece at the insertion site.

4.3.3. Quality of gas used for inflation

Inflation can be achieved by the use of air or other types of gas. Since organisms present in the abattoir environment air can originate from faeces and/or faecally-contaminated surfaces, they can include pathogens. For that reason, it can be assumed that any direct use of unfiltered air of the abattoir environment origin, to facilitate de-pelting, could cause carcass contamination. If other gases are used, their microbiological and chemical quality will determine whether they pose any risks as a source of carcass contamination.

4.3.4. Location and fate of microorganisms on the gas de-pelted carcass

On dressed carcasses, any contaminating microorganisms are likely to be confined to the tissue surfaces while the tissues below the surface are normally sterile (Gill and Newton, 1978). If pressurised gas inflation is used during de-pelting, then not only its direct effects on overall microbial load of the carcass should be considered, but whether it produces different distribution of the microorganisms on the carcass. Namely, the use of pressurised gas during de-pelting can result in de-lamination of the tissues, so one could speculate that contaminating microorganisms might be carried by penetrating gas between and/or into deeper layers. If such, during subsequent washing and chilling of the carcass, the fate of these deeper-tissue (more protected) bacteria might differ from that of bacteria present only on carcass surface.

4.3.5. Appearance of the carcass

There are views that gas penetrating the tissues during the inflation may cause the surface of the carcass to become opaque, giving a fatty appearance (Whyte *et al.*, 2000). This however would be a commercial issue of organoleptic quality of the carcass, and not a hygienic issue.

Severini *et al.,*(1994) and Trevisani *et al.,* (1996) stated that use of air inflation resulted in a better appearance of the carcasses surface and reduction of the incidence of cuts to the subcutaneous fat or muscle.

On the other hand, a research conducted in Australia, aimed at reducing blood spotting and streaking during inverted dressing, showed that air inflation during de-pelting had little effect on blood spotting and streaking (Smith and Rogers, 1993). This could mean that, where such carcass quality problem exists for other reasons, the use of air inflation should not significantly enhance it.

5. MICROBIOLOGICAL LOADS ON CARCASSES

5.1. Levels of microbial loads on carcasses de-pelted without use of gas inflation

There are great difficulties with making valid microbiological comparisons between different slaughter procedures (Ingram and Roberts, 1976), as well as between different published studies. This is primarily due to large variations in hygienic status of carcasses (and fleece) between animals from the same group, seasonal and day-to-day variations, uneven distribution of bacteria on carcasses, as well as variations in microbiological methods used. Therefore, it is generally recognised that comparisons of microbiological implications of different dressing systems are possible only in most general terms. For example, bacterial loads of carcasses dressed by various systems have been reported as:

– For "genuine" cradle system, mean total viable counts of 4.3 $\log_{10}$ cfu cm^{-2} on the carcasses was reported, but a reduction to 3.65-4.0 $\log_{10}$ cfu cm^{-2} was achievable when certain modifications were introduced in the system (so-called "Goodland Frame" and "Hybrid" cradle systems; Whyte *et al.*, 2000).

– For conventional line system, mean total viable counts can vary between, roughly, 3 and 4.5 $\log_{10}$ cfu cm^{-2} for various sites on the carcass (Bell and Hathaway, 1996).

– For inverted line system, mean total viable counts on the correlated carcass sites are usually 0.5 to >1.0 $\log_{10}$ cfu cm^{-2} lower than those found with the conventional system and shown above (Bell and Hathaway, 1996).

When comparing results from various studies published over a longer period of the time, and in spite of compliance with today's more stringent hygiene regulations, it seems that general hygienic status of dressed ovine carcasses over the past 25 years have improved only little (Bell and Hathaway, 1996). Bell and Hathaway (1996) concluded that the major sheep slaughterhouse sources of microbial contamination are fleece>workers hands>faecal pellets>knife blades. Another study indicated that microbial loads (aerobic plate counts) on visibly clean areas of carcasses can range between 3.98 and 4.44 $\log_{10}$ cfu cm^{-2}, but on sites of the same carcass contaminated with faecal material or wool the loads are much higher, 6.00 and 5.44 $\log_{10}$ cfu cm^{-2}, respectively (Biss and Hathaway 1996). These authors believe, therefore, that visible presence of faecal material or wool alone cannot be used as an indicator of the hygienic status of the carcass as a whole. It has been suggested (Bell and Hathaway 1996) that aerobic plate counts exceeding 4.4 $\log_{10}$ cfu cm^{-2} or *E. coli* numbers exceeding 3.3 $\log_{10}$ cfu cm^{-2} could be used as an indicator of direct contact with fleece and faeces, respectively. Regardless which de-pelting system is used, it seems that particularly high contamination is usually observed at the flap site, which indicates the potential usefulness of the flank sampling site in routine monitoring of dressing hygiene.

5.2. Levels of microbial loads on carcasses de-pelted with use of gas inflation

Available, more detailed information on microbial loads on carcasses de-pelted with use of gas inflation primarily originate from New Zealand (for carbon dioxide inflation) and Italy (for compressed air inflation).

5.2.1. Microbial loads on carcasses de-pelted with carbon dioxide inflation

Trials to assess if there are any effects of use of carbon dioxide inflation during de-pelting on microbial load of the lamb carcasses were conducted under both research and commercial conditions in New Zealand.

Table 3 – Aerobic Plate Count (APC) of bacteria
Results obtained at a research abattoir (Bell and Lovatt, 1999)

Mean Aerobic Plate Count (APC 30°C) for excision samples (n=25) from gas de-pelted and control carcasses for tail and hind leg gas (CO_2) injection at 700 kPa for 5 and 10 seconds

Injection Site	Sampling sites -Aerobic Plate Count (log_{10} cm^{-2})			
	Tail	Leg	Flap	Y-cut
None (control)	2.50 ±1.17	2.41 ±1.13	2.86 ±0.84	2.00 ±0.77*
Tail 10 seconds	2.18 ±1.05	1.82 ±1.07	2.54 ±1.14	2.04 ±1.23
Tail 5 seconds	2.31 ±0.92	1.56 ±1.02	2.26 ±1.01	2.36 ±1.27
Hind leg 10 seconds	2.58 ±0.76	1.82 ±0.95	2.92 ±1.34	2.74 ±1.17*
Hind leg 5 seconds	2.21 ±0.97	1.78 ±1.16	2.60 ±1.13	2.63 ±1.06*

*statistically different ($P<0.05$)

Statistical analysis of these APC counts, using the Kruskal-Wallis test, indicated that the only significance differences ($P<0.05$) between control and gas de-pelting treatments were at the Y-cut site for both the 10 seconds ($P=0.012$) and 5 second ($P=0.009$) hind leg injections. However, this significant difference was not confirmed using the same test on the *E. coli* results (Table 4). Bell and Lovatt (1999) stated that an explanation of this, probably anomalous, result, is not immediately apparent. The *E. coli* enumerations, as would be expected, were dominated by "counts" below the limit of detection <0.00 log_{10} cfu cm^{-2} (<1 cfu cm^{-2}). For statistical purposes these have been assigned the value -0.31 log_{10} cfu/cm^{-2} (0.5 cfu/cm^{-2}), as it is used in New Zealand Microbiological Database (NMD).

Table 4 – *Escherichia coli* counts
Results obtained at a research abattoir (Bell and Lovatt, 1999)

Mean *E. coli* counts for excision samples (n=25) from gas de-pelted and control carcasses for hind leg and tail gas (=CO_2) injection at 700 kPa for 5 and 10 seconds.

Injection Site	Sampling sites *E. coli* (log_{10} cfu cm^{-2})			
	Tail	Leg	Flap	Y-cut
None (control)	0.26 ±0.68	-0.29 ±0.06	0.03 ±0.58	-0.22 ±0.37
Tail 10 seconds	0.52 ±1.16	-0.24 ±0.21	0.00 ±0.47	-0.09 ±0.43
Tail 5 seconds	0.03 ±0.58	-0.12 ±0.59	-0,04 ±0.52	-0.22 ±0.18
Hind leg 10 seconds	0.71 ±1.40	-0.16 ±0.36	0.15 ±0.68	-0.11 ±0.42
Hind leg 5 seconds	0.58 ±1.38	-0.23 ±0.26	0.12 ±0.72	-0.10 ±0.42

The possibility that at the higher gas pressure (700 kPa) bacteria could force into the fascia, thus eluding recovery by surface swabbing, was considered in the optimisation of gas injection trial so excision rather than swab samples were taken for microbiological examination.

The microbiological results for the gas de-pelting trial conducted at one commercial plant are summarised in Table 5. At all sample sites, there was no any significant difference between counts for control and gas de-pelted carcasses. This was also confirmed by the same authors with analogous trials conducted at two other commercial plants in New Zealand. With the exception of the injection site, where a significant difference ($P<0.05$) in both APC and *E. coli* counts was found (Table 5). This almost certainly reflected fleece roll back occurring around the cut made for injector insertion with gas de-pelted carcasses. This cut was not made in the case of control carcasses. However, it should be noted that during trials at the research abattoir, no significant differences in bacterial counts at the injection site between inflated and control carcasses were observed (Bells and Lovatt, 1999). This could possibly be attributed to greater care taken at the research abattoir to prevent fleece inrolling at the injection site.

Table 5 – Aerobic Plate Count (APC) of bacteria.
Results obtained at an industrial abattoir (Bell and Lovatt, 1999)

Mean (n=2x30) Aerobic Plate Count (APC) (log_{10} cfu cm^{-2})and *E. coli* (log_{10} cfu cm^{-2}) for gas de-pelted and control carcasses processed at plant "X" (Injection conditions: tail injection, food grade carbon dioxide, 700 kPa for 6 seconds).

Sample site	Gas de-pelted		Control	
	APC	*E. coli*	APC	*E. coli*
Injection (tail)	3.37 ±0.40	1.57 ±0.76	1.31 ±0.90	0.21 ±0.84
Leg	0.93 ±0.70	-0.22 ±0.21	1.21 ±0.91	-0.18 ±0.28
Flap	3.01 ±0.96	0.01 ±0.46	3.02 ±0.79	-0.07 ±0.41
Y-cut	3.35 ±0.54	0.17 ±0.50	3.54 ±0.52	0.17 ±0.70

Since these industrial trials showed that gas de-pelting (with tail injection) does not adversely effect the hygienic status of lamb carcasses, as assessed at the normal, common sample sites (leg, flap and Y-cut), Bell and Lovatt (1999) concluded that there is no technical justification to prohibit subcutaneous gas injection as an ovine dressing aid on the grounds of hygiene. Although the majority of results reported by these authors relate to lambs of carcass weight between 12 and 18 kg, Bell and Lovatt (1999) also stated that the technique trialled has been successfully applied to large ram lambs of carcass weight approaching 25 kg. As indicated before, these findings were accepted by New Zealand MAF which does not restrict the use of subcutaneous gas injection as an ovine dressing aid to animals of any particular live weight.

5.2.2. Microbial loads on carcasses de-pelted with compressed filtered air inflation

Trials to assess if there are any effects of use of pressurised filtered air inflation during de-pelting on microbial load of the lamb carcasses were conducted in Italy. The results recently obtained (Table 6) with lambs slaughtered in a commercial abattoir showed that carcasses de-pelted with use of air inflation (using foreleg site) had very similar microbial loads (differences not significant) to those of carcasses de-pelted without use of inflation (Severini *et al.*, 2000).

Table 6- Mean bacterial counts (log_{10} cfu cm^{-2}) in samples (n=9) taken from shoulder immediately after de-pelting (Severini *et al.* 2000)

	Non inflated carcasses		Air inflated carcasses	
	Swab	Excision	Swab	Excision
APC (30°C)	2.24 ±0.83	2.37 ±0.38	2.28 ±0.55	2.12 ±0.78
APC (20°C)	2.24 ±0.58	1.94 ±1.19	2.36 ±0.68	2.14 ±0.81
Enterobacteriaceae (30°C)	ND*	ND*	ND*	0.45 ±0.55
Enterobacteriaceae (20°C)	ND*	ND*	0.47 ±0.58	0.40 ±0.79
Staphylococcus spp.	1.83 ±0.92	1.24 ±1.75	1.86 ±0.49	1.76 ±0.49

*ND: Not detected = log_{10} cfu/cm^{-2} <0,00

To assess general distribution of microorganisms on the surface of the carcasses de-pelted with use of air inflation, three sites of the carcasses were sampled using the swabbing technique and the results are shown in Table 7.

Table 7 – Mean bacterial Counts (log_{10} cfu cm^{-2}) swabs samples (n=9) taken from inflated lambs after evisceration of air de-pelted carcasses (Severini *et al.*, 2000)

	Shoulder	Lumbar region	Outside hind leg
APC (30°C)	3.10 ±1.20	3.43 ±0.53	3.05 ±0.53
Enterobacteriaceae (30°C)	0.12 ±0.63	1.20 ±0.88	0.62 ±0.45
Staphylococcus spp.	1.36 ±1.09	2.42 ±0.96	2.20 ±0.79

On basis of these results, the authors concluded that shoulder or the external part of the hind leg are suitable sites for sampling of carcasses air de-pelted as previously described.

In order to assess whether inflation by pressurized air cause contaminating microorganisms to be carried by penetrating gas between and/or into deeper layers, microbial loads of the carcasses were simultaneously examined by: (i) sampling the carcass surface only by swab technique, and (ii) sampling that also include deeper tissue layers by excision technique. One could speculate that any bacteria present in deeper layers could better survive drying during chilling than bacteria present on the surface only. If such, it would be expected that simultaneous examination of chilled carcasses by the swab and the excision techniques could show significant differences in microbial counts.

Table 8- Mean bacterial Counts (log_{10} cfu cm^{-2}) in samples (n=6) taken from shoulders of carcasses after 24-hours-chilling (Severini *et al.*, 2000)

	Non inflated carcasses		Air inflated carcasses	
	Swab	Excision	Swab	Excision
APC (20°C)	2.17 ±0.74	2.90 ±0.40	2.86 ±0.63	3.38 ±0.36
Enterobacteriacea (20°C)	0.92 ±1.30	1.32 ±0.03	1.45 ±0.98	1.65 ±1.10

On the basis of these results, Severini *et al.,* (2000) concluded that no significant differences in microbial loads on inflated and non-inflated carcasses were observed neither by excision samples nor by swab samples. This would mean that no different distribution or fate of micro-organisms was observed on air inflated carcasses as compared with non-inflated carcasses. In addition, considering the economical loss due to excision sampling, the authors proposed that swab samples are adopted for microbiological examination of air de-pelted carcasses in commercial abattoirs.

6. POTENTIAL MEASURES AIMED AT REDUCING CARCASS CONTAMINATION DURING DE-PELTING

6.1. General preventive measures related to ovine de-pelting

6.1.1. Assessing animal cleanliness

In the UK for example, cleanliness of sheep is visually scored using five-category scoring scale (The MHS Operation Manual). Operators have to establish a system for identifying and diverting dirty animals from being presented for ante-mortem inspection. The Official Veterinary Surgeon (OVS) has the power to prohibit the entry into the slaughterhall of dirty sheep or to request the animals to be cleaned.

6.1.2. Pre-slaughter cleaning of sheep

6.1.2.1.Crutching

It is commonly believed that "crutching" of sheep (shearing the most contaminated region around the anus) can reduce the microbial load on the carcass, but Roberts (1980) found that this did not reduce the bacterial numbers on the carcass.

6.1.2.2.Washing

When considering pre slaughter washing of sheep, it seems that fleece wetness is a major factor enhancing microbiological contamination of the

carcass. Therefore, pre-slaughter washing of sheep will have positive effects only if the washed animals are allowed sufficient time to dry before they are slaughtered (Newton *et al.,* 1978; Patterson and Gibbs, 1978).

6.1.3. Measures to prevent direct transfer of dirt from fleece to the carcass during de-pelting

The practical and hygienic implications of some intervention measures aimed at improving hygienic performance of standard "cradle" de-pelting system were investigated in the UK (Whyte *et al.*, 2000, Tinker personal communication), and are briefly introduced below.

6.1.3.1.Wool clipping

By clipping, the wool could be removed from the cut lines on the carcasses, but advantages of providing clean cut lines however were outweighed by a) the contamination of the carcass and operatives' hands by small hair particles, b) lack of fleece for the operatives to grip and c) the time taken to clip the fleece (Tinker, personal communication). Clipping only gave good results in terms of gross contamination, assessed by subjective visual examination, if the animals were clipped along the pelt cut lines and then housed in clean conditions 7 to 14 days in advance of slaughter (Whyte *et al.*, 2000). This procedure removed gross contamination of the fleece and allowed time for limited regrowth of hair and shedding of loose hair particles.

6.1.3.2.Holding back the fleece

So-called crocodile clips were used to hold back the fleece, but the method was assessed as hampering de-pelting operation and time-consuming (Tinker, personal communication). Use of so-called bulldog clips to prevent contact between the fleece and the underlying tissue, resulted in higher pelted carcass contamination due to the contamination on the hands of slaughtermen during clip application (Hadley *et al.*, 1997).

6.1.3.3.Impermeable paper placed between pelt and the carcass

There are opinions that glossy paper sheets placed on the sternum and inguinal regions can be very useful in preventing transfer of dirt from fleece to the carcass (Gracey *et al.*, 1999), but some studies found no positive effect in terms of reduction of microbial loads (Bensink, 1972; Hadley *et al.*, 1997) although visible contamination was reduced.

6.1.3.4.Reduction of airborne contamination

Abattoir layout determines to a large extent the passage of airborne contamination, and baffles between carcasses and positive air pressure in the abattoir relative to the lairage can reduce airborne contamination (Worfel *et al.*, 1996).

6.2. Specific preventive measures for the gas inflation method

6.2.1. Injection site

According to Bell and Lovatt (1999), to prevent/reduce contamination of the subcutaneous tissue during insertion of the needle, a small area of skin at the insertion site should be cut away so that the needle only passes through the underlying tissue. Subsequently, fleece roll back around the cut made for injector insertion should be prevented. The authors tested four insertion sites (tail, belly mid-line, hind leg and fore leg) and finally recommend tail site for the commercial implementation of gas assisted pelt removal due to the efficiency of pelt removal reasons. If tail site is used, the needle is inserted just above the tail stump, to its full length just under the skin along the spine. Bell and Lovatt (1999) stressed that for the best results the injector must be placed between the skin and the underlying fascia, and such placement is more difficult where there was little loose skin as is the case at the leg sites. On the other hand, Severini *et al.,* (2000) reported the successful use of front leg injection site for compressed air inflation.

6.2.2. Needle sanitisation

Transfer of microorganisms between subsequent different animals via use of the same injection needle should be prevented. Bell and Lovatt (1999) found that after gas injection the mean total viable count on the injection needle was 2.10 $\log_{10}$ cfu cm^{-2} but can be reduced by "sanitisation“ in hot water (82^oC) to 0.94 $\log_{10}$ cfu cm^{-2}.

6.2.3. Gas pressure

The greater the amount of gas injected, the easier subsequent de-pelting is and the lower the pelt strain levels, but clearly there are limitations with respect to gas injection (Bell and Lovatt, 1999). Although the higher pressure and longer duration of application seem to be superior to the lower pressure/shorter time combinations, inflation of too large volumes of gas and/or high pressures should be prevented as it could result in bursting of the skin with the carcass contamination as a most probable consequence. When using tail injection site, Bell and Lovatt (1999) found that inflation with carbon dioxide at 700 kPa for 8 sec. is superior to the lower pressure shorter time combination. When using front leg site, Severini *et al,* (2000) reported 900 kPa for 10-15 sec.

6.2.4. Type and quality of the gas

The gas used for the inflation must be either food grade e.g. carbon dioxide (Bell and Lovatt, 1999) or filtered compressed air (Severini *et al.*, 2000) according to well defined specifications. In both cases the final result should be the complete absence from the gas of any microbiological and chemicals hazards affect the hygienic status of the carcasses. On the other hand, the choice of gas may be relevant for the safety of the working environment. Namely, if air is used, there are no major implications for the slaughter floor environment. However, if gases that could change normal composition of the abattoir atmosphere (e.g. carbon dioxide) are used, the issue of safety of people operating in that environment must be properly addressed.

7. CONCLUSIONS

(1) A major source of carcass contamination of sheep and lamb is the fleece.

(2) The de-pelting technique is one of the most important factors affecting direct or indirect contamination from fleece to carcass. Different de-pelting techniques result in different levels and distributions of carcass contamination.

(3) On the basis of the available scientific and technical knowledge, there is no indication that gas inflation used as an aid to the classical de-pelting techniques (conventional and inverted) is likely to give rise to additional risk of microbiological contamination to the carcass, provided that:

(a) The hygienic principles are respected, in particular:

– Prevention of contamination of the subcutaneous tissue during insertion of the needle;

– Prevention of transfer of contamination between animals *via* injection needle;

(b) Any gas methods used to aid in de-pelting are applied correctly to avoid e.g.: too high gas pressure and too long duration for injection with possible bursting of the skin and heavy contamination of the carcass.

(4) There is, however, a lack of data on the microbiology of carcasses obtained by the use of different techniques under field conditions. At present, recommendations about the use of gas inflation therefore can be given only on the basis of few experimental data and, therefore, are based on general hygiene concepts.

(5) The use of gas may represent a critical factor, as it can be a source of contamination of the carcass. In addition, the occupational health and safety implications of using gases in abattoirs need be considered.

8. RECOMMENDATIONS

(1) Gas inflation for de-pelting of ovine carcasses should be used only in slaughter plants with a validated HACCP-based system.

(2) Depending on the dressing method used, all measures should be taken to reduce the risk of contamination of the carcasses. With respect to gas de-pelting techniques, the following issues deserve attention:

(a) site of gas injection;

(b) sanitising procedure of needles;

(c) type and quality of the gas;

(d) duration and pressure profile of the gas inflation.

(3) Further research should be encouraged to gather more relevant information, particularly about the microbiological condition of the carcasses and the optimal procedure in using gas de-pelting techniques.

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