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Spray washing of lamb carcasses

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Introduction

The meat trade assesses carcass appearance on the basis of visual cleanliness and "bloom", which is a combination of colour, fat flaking, tissue tearing and wetness etc. Legislation banning as unhygienic the use of wiping cloths to clean carcasses after slaughter came into force in Britain in 1968. However, the trade was left without a satisfactory alternative method of producing visually clean meat. Many butchers are reluctant to adopt spraywashing techniques in the conviction that contact with water damages "bloom" and keeping quality. Cleaning aids have emerged which are as reprehensible as the wiping cloth. The greatest problems are presented by lamb carcasses because of the high level of contamination of the fleece.

Little has been published on methods of reducing carcass contamination and nothing on spray washing. In Australia and New Zealand carcass contamination is minimised by pre-slaughter cleaning. However, British abattoirs generally are not equipped for this. A washing system is therefore required that will reduce contamination after slaughter.

Furthermore, such a system must be adaptable to the rapid throughputs of commercial operation.

This paper present results of experiments to evolve a workable and effective system of carcass washing by means of water sprays.

Free residual chlorine in water has a powerful bacterial action which has beneficial effects in poultry processing (1) but there is no information on lamb carcasses. Although there are no regulations governing chlorination, an official report (2) states that: "Provided the extent of chlorination is controlled to ensure that the produce as sold to the consumer contains no free chlorine, we see no reason to bring its use as a processing and hygiene aid within the scope of the Preservatives Regulations". The effect of chlorination was therefore investigated over a range of concentration.

Materials and methods

Carcasses

In preliminary field observations in eleven abattoirs in the south west of Britain samples of twelve lambs were selected at random from the production line in seven representative instances.

In controlled experiments in the licensed abattoir of the Meat Research Institute, lambs of 17-24 kg carcass weight were slaughtered by electrical stunning and cutting their throats, bled for about 5 min and the skin removed on a low trolley within 10 min of death. In experiments 1-12 a high but not unrepresentative level of contamination of relatively clean carcasses was ensured by wiping the fleece over the freshly exposed skin surface.

Usually, six lambs were subjected one after another to any given treatment, and compared with six more slaughtered at about the same time subjected to some other treatment. In all about 600 lambs were used.

Types of spray

Of numerous possible types of spray jet, three were selected with the same pressure/ flow rate characteristics:-

(i) full cone rain jet (uniform pattern of distribution, low impact);
(ii) flood jet (flat wide angle spray of low to medium impact);
(iii) fan jet (flat spray, high impact).

These sprays were operated at a standard distance of one foot (25 cm) from the carcass surface.

Water temperature

After preliminary trials, supply water temperatures of 15°C and 90°C were adopted as standard "cold" and "hot" extremes. In certain experiments 55° and 75°C were employed for special reasons.

The temperature of the spray on impact was measured by placing thermocouples on the carcass surface.

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Water pressure

A compressed air driven pump was used to provide water from a feed tank at dynamic line pressures of 33 and 165 lbf/in^2 (234 and 1130 kN/m^2) which were adopted as standard "low" and "high" water pressures, and in later experiments 100 lbf/in^2 (689 kN/m^2) was used.

A prototype unit using live steam injection into the water supply line was tested. This system increased temperature and pressure simultaneously and required no pump.

The relation between the surface impact and the spray line pressure was measured by offsetting the spray impact on a small plate against a sensitive balance.

Duration of washing

The standard wash time initially was 1 min and in some experiments ½ min, further reduced in commercial trials.

Chlorination

A chemical dosage pump was used to inject hypochlorite solution between feed tank and spray pump, using the fan jet operating at 100 lbf/in^2 dynamic line pressure. Chlorine concentrations of approximately 15, 60, 90, 180 and 340 ppm were used.

Visual assessment

Carcasses were graded, using a 5 point scale from "perfect" to "very poor", equal importance being attached to cleanliness immediately after washing, and "bloom" after 24 and 48 h.

Bacteriological assessment

Surface bacterial counts were measured by swabbing whole carcasses (3) before and 5 min after washing, followed by dilution, plating out and incubating at 1°, 25° and 37°C. In chlorination experiments 0.5 ml of 1 N sodium thiosulphate was added to each pair of wet and dry swabs to neutralise any residual chlorine.

Weight changes

The effect of spraying on weight was measured on batches of 18 carcasses: six sprayed for 1 min, six for ½ min, and six wiped with sterile cloths. The carcasses were individually weighed 5 min after treatment, and then hung at ambient conditions for 4 h. They were then transferred to a chill room at +2°C and reweighed daily for 2 to 6 days. In all, 126 carcasses were treated in these tests.

Results

Fig. 1 shows that existing commercial cleaning techniques varied considerably and also their visible effectiveness. Water temperature varied from 15° to 70°C, pressure from ~ 0 to 120 lbf/in^2 (825 kN/m^2), and wash time from 5 sec to 2½ min per carcass. Bacterial reductions were generally marginal and some processes slightly increased the contamination. The sole highly effective procedure (A) that resulted in 90% reduction in bacterial count was exceptional and ultimately discontinued.

There was a marked fall in the temperature of hot water sprays after leaving the nozzle. Water delivered at 90°C had fallen to 63°C at impact on a carcass at 1 ft (25 cm) distance. There was also a considerable fall in pressure, water at 100 lbf/in^2 (689 kN/m^2) falling to 0.15 lbf/in^2 (1.03 kN/m^2) in 1 ft.

Fig. 2 shows the effect of the different spray treatments on visual appearance of carcasses. Cold water sprays, with the exception of the fan jet at low pressure, proved unsuitable because of either poor cleaning or surface damage, especially at high pressures. Hot water sprays effected the best cleaning and good bloom with fan jets at either low or high pressure, the latter being marginally superior. Hot water imparted a slight "milkiness" initially, which diminished on cooling and was virtually undetectable after 24 h.

Table 1 gives the bacteriological results of spraying. Analysis is complicated by the considerable variation in initial contamination. Thus, it is difficult, taking the 37°C counts, to compare in experiments 8 and 9 a reduction from 108 to 31 million with one from 4.9 to 3.4 million. In 5 instances out of 6, cold water sprays increased the counts at 1°C. Cold water tubs used in the dressing of lamb carcasses are known to be a potent source of cold-tolerant bacteria (4). However, visual assessment indicated the superiority of hot water systems, where the 1°C counts did not increase.

Table 1. Numbers of bacteria (millions/carcass) before and after spraying, incubated at 37°C, 25°C and 1°C.

Spray Type	Temperature	Pressure	Experiment Number	37°C Incubation		25°C Incubation		1°C Incubation	
				Before	After	Before	After	Before	After
				Bacteria x 10^6	Bacteria x 10^6	Bacteria x 10^6	Bacteria x 10^6	Bacteria x 10^6	Bacteria x 10^6
Rain	Cold	Low	1	15	12	77	53	8.6	4.1
Rain	Cold	High	2	60	18	178	7.2	6.9	8.1
Flood	Cold	Low	3	73	50	92	85	1.2	1.4
Flood	Cold	High	4	87	29	164	92	3.0	3.5
Fan	Cold	Low	5	64	15	51	23	0.25	1.2
Fan	Cold	High	6	30	23	37	30	0.17	1.4
Fan	Hot	Low	7	81	12	196	56	11	1.0
Fan	Hot	High	8	108	31	164	31	1.2	0.11
Flood	Hot	Low	9	4.9	3.4	84	41	0.16	0.07
Flood	Hot	High	10	7.2	2.9	89	17	0.21	0.15
Rain	Hot	Low	11	28	6.9	54	26	1.9	0.40
Rain	Hot	High	12	93	12	192	32	0.66	0.21

Analysis of variance of the counts before spraying, classified by treatment, shows significant interaction due to variation in initial contamination that confounded the effect of spraying. Because the efficiency of cleaning might best be reflected by the numbers of bacteria remaining after treatment regardless of initial contamination, counts after spraying are analysed in Table 2.

At all incubation temperatures, residual counts were higher on the carcasses sprayed with cold water, the difference being greatest in the 1°C counts. This apparent 10-fold difference in the count of cold-tolerant bacteria when using hot water is partly due to the anomalous increases noted with cold water systems. Nevertheless, it appears that hot water not only leaves fewer surviving bacteria but also preferentially removes those bacteria likely to grow and cause spoilage during subsequent refrigerated storage of meat.

Comparison between ½ min and 1 min spraying using the fan jet at 100 lbf/in² dynamic line pressure, and 75°C (corresponding to an impact temperature of 56°C), showed that there was little difference in visual appearance. The greater part of the visible contamination was quickly removed by the spray; benefit from longer spray times was only apparent when patches of wool adhered stubbornly to the carcass.

Table 2. Means of residual bacteria (millions/carcass) after spraying

Spray Type	Expt No	Water	Mean of 37°C counts	Average of means	Mean of 25°C counts	Average of means	Mean of 1°C counts	Average of means
Rain	1	Cold	12	24.5	53	48.4	4.1	3.3
Rain	2		18		7.2		8.1	
Flood	3		50		85		1.4	
Flood	4		29		92		3.5	
Fan	5		15		23		1.2	
Fan	6		23		30		1.4	
Fan	7	Hot	12	11.4	56	33.8	1.0	0.32
Fan	8		31		31		0.11	
Flood	9		3.4		41		0.07	
Flood	10		2.9		17		0.15	
Rain	11		6.9		26		0.40	
Rain	12		12		32		0.21	

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Bacterial counts revealed a significant difference between the spraying times. The mean differences between the logarithms of the counts before and after spraying (in effect, the ratio between them) for 1 min were significantly greater ($P < .001$) than for $\frac{1}{2}$ min; the respective ratios being 5.1 and 2.3.

The results of chlorination experiments show that (1) the higher the concentration of chlorine, the more effective the spray; (2) hot water gave better results than cold, both in the presence and absence of chlorine; and (3) hot water was particularly advantageous in combination with low concentrations of chlorine which otherwise were not very effective.

For statistical analysis, five levels of chlorination were assumed, though chemical analysis of samples shown in Table 3 indicated some differences.

Table 3. Measured available chlorine concentrations (p.p.m.) at high and low water temperatures.

	Chlorination level				
Water temperature	1	2	3	4	5
High	357	172	93	62	15
Low	330	195	95	67	16

Analysis of bacterial counts at 25°C in Table 4 shows a highly significant effect of level of chlorination ($P < .001$), with no temperature effect, and no interaction between them.

Table 4. Arithmetic mean differences (millions/carcass) in bacterial numbers for various chlorine levels.

Chlorine level	1	2	3	4	5
Mean difference	711	186	60	50	35

This analysis takes no account of the data from control carcasses sprayed at the same time. When they were analysed for effect of water temperature, there was a clear indication (though not quite statistically significant at $P < .05$) of a difference, the means of differences (millions organisms/carcass) for hot and cold water being 123.2 and 65.1 respectively.

Clearly, the addition of chlorine to spray water can be advantageous in improving the bacteriological quality of the washed carcass and it is most efficacious with hot water. Any residual chlorine would exert an antibacterial effect during subsequent chill storage.

The weight changes 5 min after cleaning were:- 1 min spray, + 1.04%; $\frac{1}{2}$ min spray, + 0.90%; wiped, -0.16%. Table 5 gives the results for weight losses subsequently. For all times of storage (except the single trial at 144h) there were highly significant differences ($P < .01$) between the wiped and sprayed carcasses. The consistently lower weight loss at 1 min as compared with $\frac{1}{2}$ min was not statistically significant. Nevertheless, it is clear that sprayed carcasses lose about $\frac{1}{2}$% less weight than wiped carcasses during refrigerated storage.

As a result of foregoing, it was deduced that the most successful combination was a fan jet used for 1 min at 100 lbf/in^2 dynamic line pressure, making an impact of 0.15 lbf/in^2 and a temperature of 60°C at the surface of the carcass, the water flow rate being 8.5 l/min. Although the prototype commercial live steam injection system was unable to match these optimal conditions it nevertheless produced carcasses of a reasonably good visual and bacteriological standard of cleanliness.

The experimental spray system, consisting of fan jet with pump and feed tank, was tried in a lamb line at a large commercial abattoir. The required line pressure and flow rate were obtained, but the maximum feed water temperature was only 55°C, corresponding to a surface water temperature of 42°C. Carcasses were sprayed at the rate of 120 per hour.

The visual appearance of the sprayed carcasses was very good. 12 carcasses selected at random from the line were swabbed. The residual counts achieved were relatively low, although the percentage reductions were not as good as those achieved experimentally, largely due, no doubt, to the lower water temperature and spray time of less than 20 sec.

Table 5. Weight losses in sprayed and wiped lamb carcasses (g/kg initial weight)

Time Interval (hours)	Number of trials	Wiped	½ min spray	1 min spray
24	5	24.1	21.6	20.5
48	7	29.0	26.6	25.1
72	2	31.3	28.9	26.4
96 or 100	3	39.2	36.6	34.3
144	1	43.7	39.3	36.3

Discussion and Conclusions

1. A limited investigation into the washing practices currently in use in abattoirs has shown that the majority of the cleaning systems are ineffective, particularly in removing bacteria. Some are as detrimental as the wiping cloths they replace.

2. The long term solution is no doubt pre-slaughter cleaning of animals. However, a spray system has been devised that markedly reduces contamination of lamb carcasses.

3. In an experimental investigation on some 600 lambs, a fan jet used at a dynamic line pressure of 100 lbf/in^2 (689 kN/m^2) with a surface water temperature of 60°C and flow rate of 8.5 l/min has been shown to yield consistently clean carcasses of good "bloom" and relatively low numbers of residual bacteria. Hot water gave carcasses of better bloom with fewer bacteria than cold water. The spray time had little effect on the visual appearance of the carcass, but carcasses sprayed for 1 min had statistically fewer residual bacteria than carcasses sprayed for ½ min. As the assessment of "bloom" varies considerably from one abattoir to another, the recommended values of spray temperature and pressure might therefore be varied to suit individual preferences.

4. Sprayed carcasses were found to lose significantly less weight, based on the dry carcass, than carcasses cleaned with sterile wiping cloths.

5. In certain circumstances the very wet carcasses produced by spraying could cause problems in terms of keeping quality. Difficulties might occur where carcass surfaces remained wet in storage and consequently provided sites for bacterial growth. No such problems occurred in this investigation, however, because excess surface water was removed during hanging for 4 hours in a well-ventilated hall and in storage in chill rooms with adequate capacity for removal of water vapour. Abattoirs with poor refrigeration capacity might require the removal of excess moisture by hanging in an air stream.

6. The use of chlorinated water was beneficial at all concentrations from 15 to 350 p.p.m. The effectiveness 5 min after washing increases with concentration and increased benefits may well be obtained with stored carcasses.

References

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2. Ministry of Agriculture Fisheries and Food. Food Standards Committee Report on Preservatives in Food (1959).
3. Hudson, W.R., Ingram, G.C. and Kitchell, A.G. (1970) Bacteriological carcass sampling technique (unpublished).
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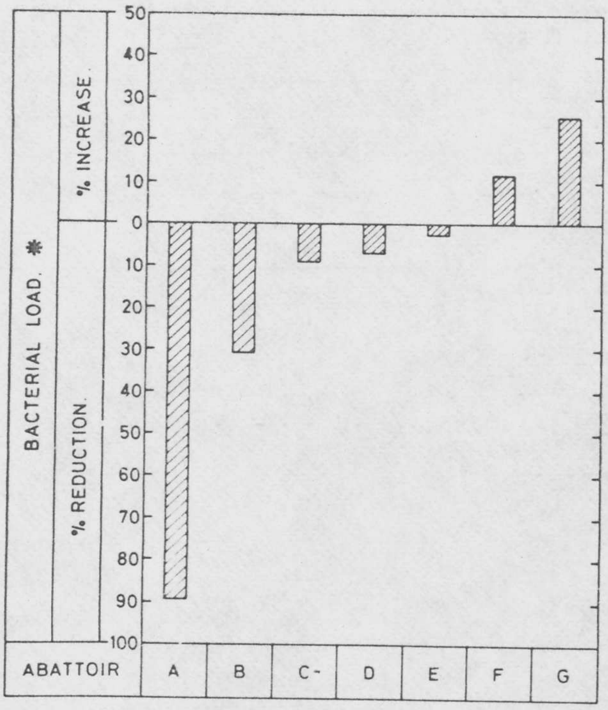
A COMPARISON OF CARCASS CLEANING METHODS USED IN COMMERCIAL ABATTOIRS.



(A) Paper towel plus hot water (30 sec) - high pressure cold water spraying (30 sec) - paper towel (30 sec)

(B) Warm water high pressure spray (30 sec) - paper towel

(C) Warm water spray (45 sec) - air cooled

(D) Coldwater commercial spray (15 sec)

(E) Scrubbed - cold water spray (5 sec)

(F) Car wash brush warm water (105 sec) - paper towel (15 sec)

(G) Cold water commercial spray (5 sec)

* Count plates incubated at 25°C

Figure 1

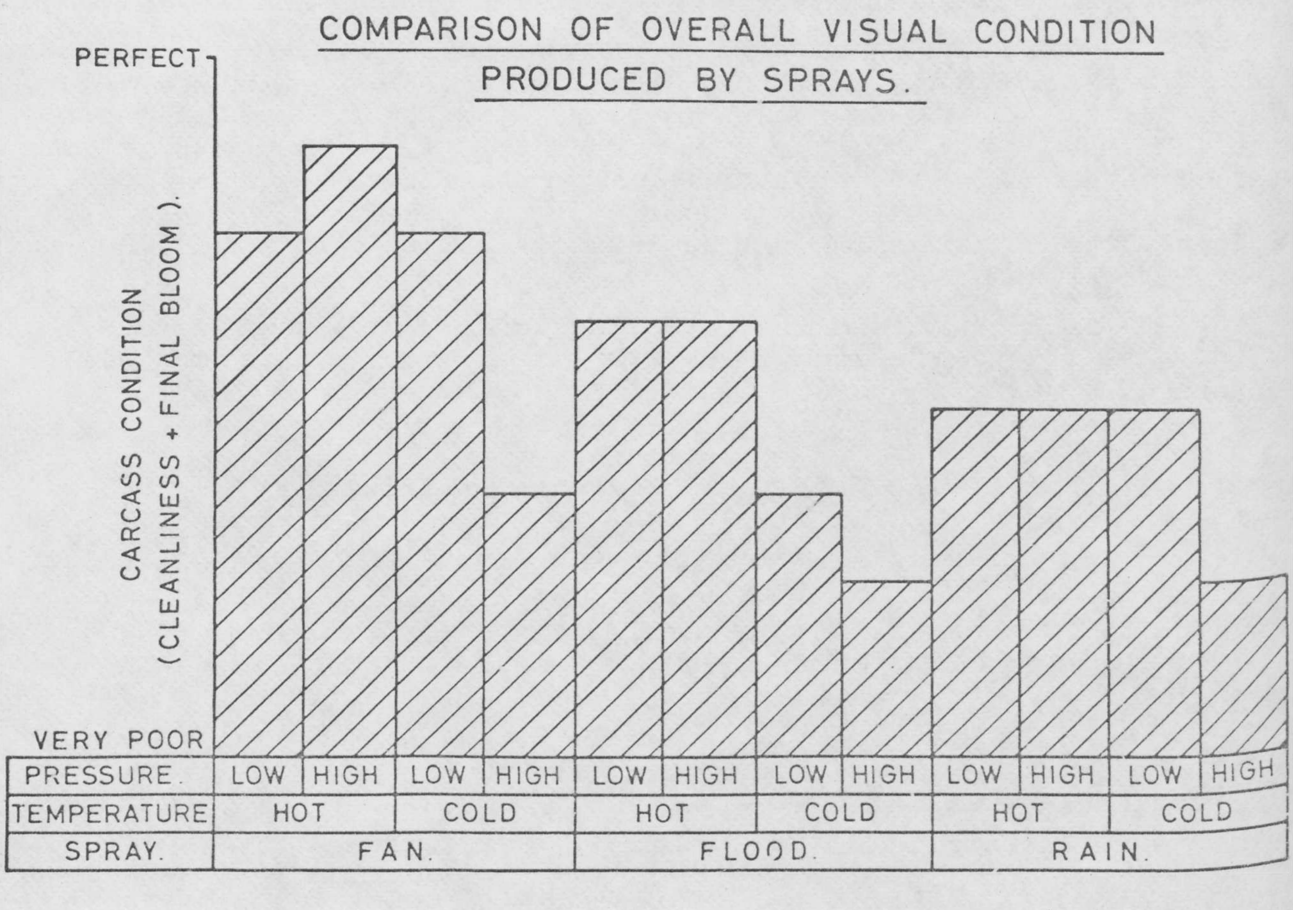


Figure 2

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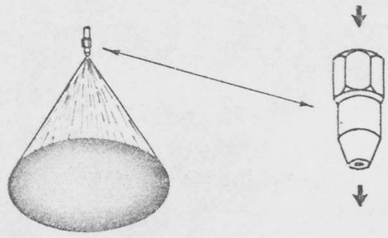
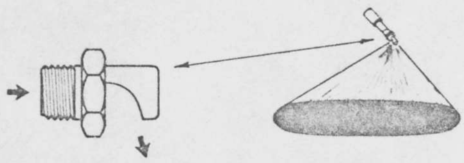
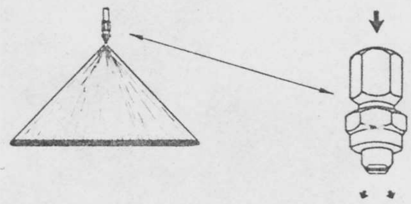


Rain Jet



Flood Jet



Fan Jet

Spray Nozzles