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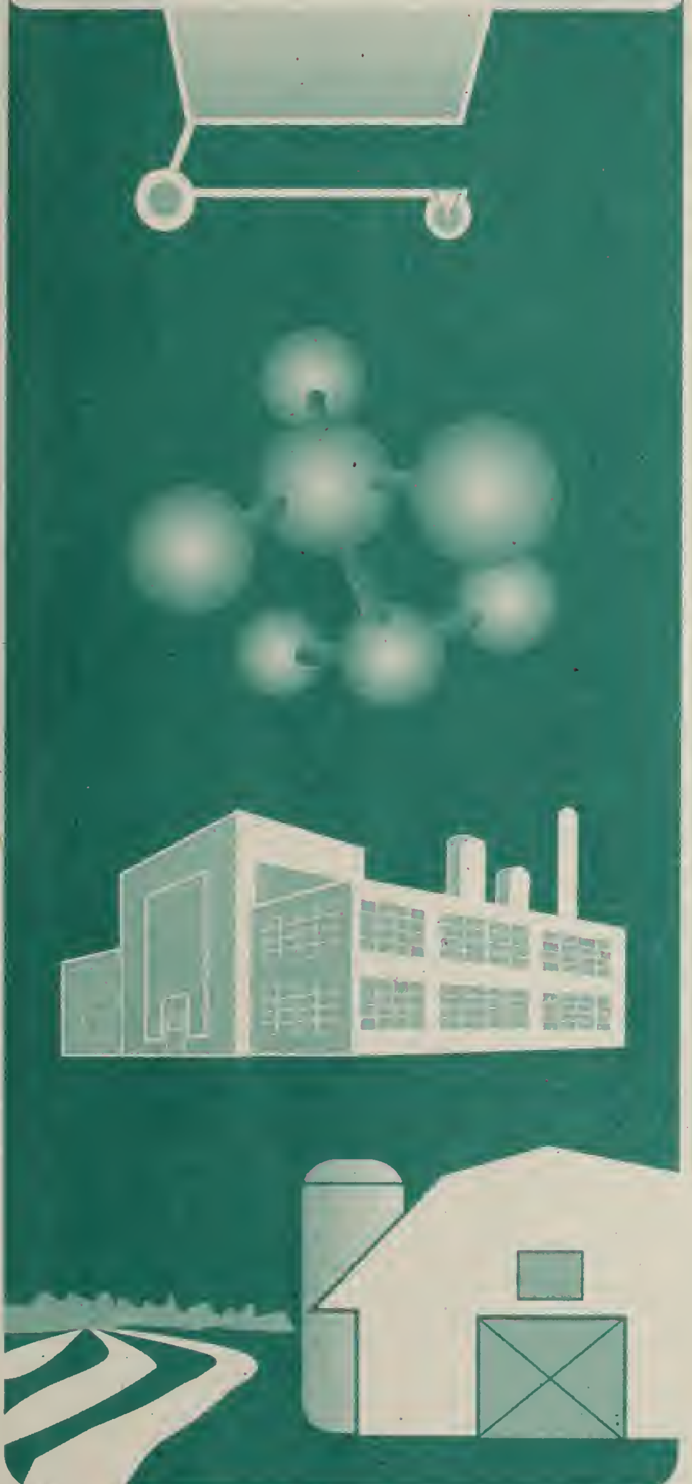

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Microbial effects of trimming, vacuum cleaning or vacuum-hot water cleaning of beef or sheep carcasses in commercial dressing processes

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Microbial effects of trimming, vacuum cleaning or vacuum-hot water cleaning of beef or sheep carcasses in commercial carcass dressing processes

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SUMMARY

Operations in commercial beef and sheep carcass dressing processes for removing visible contamination by vacuum cleaning, hot water-vacuum cleaning, or trimming of the dressed carcass were similarly ineffective for removing bacterial contaminants from carcasses. Such operations should therefore be regarded as Quality Control Points for assuring the appearance of carcasses, but not as Critical Control Points for assuring meat safety. As there are no safety considerations, a treatment for removing visible contamination can be selected with regards to only commercial convenience and cost provided that the treatment removes the visible contamination.

RÉSUMÉ

La mise en place, dans des usines commerciales de procédés utilisant des aspirateurs et aspirateurs à eau chaude ainsi que le parage des carcasses pour éliminer les contaminants visibles sur les carcasses de boeufs et de moutons se sont tous avérés inefficaces pour éliminer la contamination bactérienne. De tels procédés devraient donc être classés comme points de contrôle de la qualité qui assurent une bonne apparence des carcasses et non pas comme points de contrôle critiques pour garantir la salubrité de la viande. Puisque la salubrité de la viande n'est pas en cause, un traitement peut donc être choisie d'après le coût et l'attrait commercial, aussi longtemps que le traitement élimine les contaminants visibles.

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Introduction

Meat inspecting authorities require that visible contamination be trimmed from carcasses before they are deemed acceptable for human consumption (USDA, 1995). Despite the general requirement for trimming to remove visible contamination, it has been usual North American practice to remove hairs from some portions of carcasses, such as the hocks of cattle and the hind quarters of sheep, by application of a vacuum head to the meat. Those traditional methods of removing visible contamination from carcasses have recently been supplemented by the introduction of vacuum cleaning equipment which also delivers a stream of hot water and/or jets of steam, of pasteurizing temperatures, onto the meat surface.

In mandating trimming and permitting the other treatments for the removal of visible contamination from carcasses, meat inspecting authorities have assumed that the microbiological as well as the aesthetic conditions of carcasses will be improved by the removal of visible contamination (USDA, 1996). Indeed, laboratory studies have shown large reductions in bacterial numbers as a consequence of removing visible filth from experimentally contaminated meat by trimming or vacuum-hot water cleaning . (Dorsa *et al.* 1996; Hardin *et al.,* 1995; Kochevar *et al.*, 1997; Phebus *et al.*, 1997). However, there is in practice no correlation between visible and microbiological contamination of carcasses (Biss and Hathaway, 1995 and 1996; Jericho *et al.,*. 1993), while studies of beef and sheep carcass dressing processes have shown that the trimming operations at the end of such processes have no effect upon the microbiological condition of the carcasses (Gill *et al.,* 1996; Gill and Baker, 1997). There is then the possibility that in practice vacuum-hot water cleaning is similarly ineffective for improving the microbiological condition of carcasses.

In view of the current requirements that meat packing plants establish HAACP systems for their dressing processes, and the wide adoption of vacuum-hot water cleaning of carcasses, it would seem necessary that the microbiological effects of vacuum-hot water cleaning operations be properly identified, so that such operations can be properly classified as Critical Control Points in HACCP systems if they substantially improve the microbiological conditions of carcasses, but as Quality Control Points in Total Quality Management (TQM) systems if they serve only to improve the appearance of carcasses by the removal of visible contamination (Gill *et al.,* 1997; MFSC, 1992).

Assessment of the microbiological effects of processes and operations

A process is a series of related operations to which input materials are subjected to yield a product. The carcass dressing process is considered to be constituted of all the operations to which the carcass is subjected between bleeding of the animal and entry of the carcass into a chiller. The microbiological effects of the process can be assessed by determining the mean numbers of bacteria on the carcasses that emerge from the process. The effects of individual skinning operations or groups of such operations can be assessed by determining the mean numbers of bacteria on the areas effected by the skinning operation(s) immediately after the operation(s) is completed. The effects of other operations can be assessed by determining the numbers of bacteria on the areas affected by the operation(s) before and after the operation(s).

To assess the microbiological condition of the carcasses passing through a process, or of a portion of their surfaces, at any point in a process, a single sample is obtained by

swabbing a randomly selected, 100 cm^2 area of the carcass surface on each of 25 carcass selected at random as they pass the point of interest in the process. The numbers of total aerobic counts, coliforms and *Escherichia coli* recovered on each swab are determined. As the bacteria on meat are log normally distributed, a set of 25 log counts is sufficient for estimation of the mean and the standard deviation for the log numbers of bacteria on the whole population of carcass which pass through the process.

However, it must be appreciated that the mean log is always less than the log of the arithmetic mean unless the standard deviation is zero. Consequently, when bacteria on meat are redistributed by an operation with reduction of the standard deviation, the mean log will increase despite there being no change in the total numbers of bacteria on the meat. Thus, the microbiological effects of a process or operation must be assessed by reference to the logs of the arithmetic mean numbers of bacteria on the meat, which can be calculated from the mean log and the standard deviation for each set of 25 log values.

If samples containing no bacteria are frequent in a set, estimation of the log mean is not possible. In such cases, assessment of microbiological effects is still possible by considering the total number of bacteria recovered in each set of 25 samples.

General microbiological effects are assessed, for QM purposes, from total aerobic count data. Contamination with organisms possibly hazardous to health is assessed, for HACCP purposes, from *E. coli* count data. Coliform counts are collected incidentally to the collection of *E. coli* counts, but the coliform count data can supplement the other data and indicate the likely origins of some contamination.

The procedures have been fully described in various publications (Gill and Baker, 1997; Gill and Bryant, 1997; Gill *et al.* , 1996). The statistics referred to in assessments are: $\bar{x}$, the mean of a set of 25 log values; s, the standard deviation for a set of 25 log values; no, the number of samples in a set of 25 in which bacteria were not detected; log A, the log of the mean numbers of bacteria on the meat, calculated from the formula $\log A = \bar{x} + \log_n 10 . s^2/2$; N, the log of the total number of bacteria recovered from 25 samples.

Generally, if the values for log A before or after an operation or process differ by one or more, the operation or process can be assessed as microbiologically effective. Usually, the differences in the values for N for sets of data obtained from product before and after an operation or process will parallel the differences in the values for log A. When log A values cannot be realistically calculated because of large numbers of bacteria-negative samples, then an operation or process can be assessed as microbiologically effective when the values for N before or after the operation or process differ by one or more.

When pairs of log A or N values differ by between 0.5 and 1, the possibility of some marginal microbiological effect can be considered. However, when pairs of log A or N values differ by less than 0.5, the operation of process must be regarded as microbiologically ineffective.

Trimming

During the commercial dressing of beef and sheep carcasses, occasional trimming of carcass to remove gross, visible contamination may be performed during some skinning or eviscerating operations. However, most trimming is performed as a single operation or series of operations after

the completion of all other operations except the final wash.

The effects of a series of trimming operations at the end of a high speed, beef carcass dressing process were examined, by sampling sites randomly selected from the whole surface of the carcass, and with the collection of samples before and after the trimming operations. The equivalent statistics for each type of count before or after the treatment were similar (Table 1), which indicates that the trimming operations had no effect of practical importance on the microbiological condition of the carcasses produced from the process.

A trimming operation performed on the hindquarters of sheep carcasses immediately before they were washed was equally without effect in the microbiological condition of the carcass hindquarters (Table 2).

Those data indicate that trimming applied as a finishing treatment to dressed carcasses is wholly ineffective as a means of removing microbiological contamination. Such operations should therefore be regarded as only Quality Control Points for assuring the acceptable appearance of carcasses.

From that it follows that a policy of "zero tolerance" of visible contamination on dressed carcasses is an ineffective means of assuring the safety of meat with respect to microbiological contamination, as the removal of visible contamination from carcasses leaving the dressing line will not improve the microbiological condition. In fact, such a policy may well be counter productive for safety, as undue emphasis on visible contamination is likely to distract from proper consideration and control of hazardous microbiological contamination.

Despite the trimming of dressed carcasses being ineffective for controlling the microbiological condition of the meat, it should not be assumed that trimming must be equally ineffective as a decontaminating treatment under all circumstances. Where an area of the carcass is known to be commonly heavily contaminated with bacteria during a particular operation, then routine trimming of that area immediately after the operation and irrespective of the presence or otherwise of visible contamination may be an effective means of controlling microbiological contamination. That use of trimming, and the use of trimming in the proper handling of misprocessed carcasses, such as carcasses contaminated by gut spillage or dropping to the floor, will have to be investigated.

TABLE 1: TRIMMING OF BEEF CARCASSES

Statistics for sets of 25 total aerobic counts (cfu/cm^2), coliform counts (cfu/100 cm^2) or *Escherichia coli* counts (cfu/100 cm^2) obtained from randomly selected sites on carcasses selected at random from those entering or leaving a series of trimming operations at the end of a beef carcass dressing process.

Count	Stage of the process	Statistics				
		$\bar{x}$	s	no	log A	N
Total	Before trimming	2.41	1.16	0	3.96	4.84
	After trimming	2.50	1.03	0	3.72	4.75
Coliform	Before trimming	1.31	1.13	3	2.78	3.84
	After trimming	1.28	1.11	4	2.70	4.02
E. coli	Before trimming	1.14	1.12	4	2.58	3.81
	After trimming	1.06	1.09	4	2.43	4.01

$\bar{x}$=mean log; s=standard deviation; no=samples without bacteria; log A=log mean; N=log total number recovered.

TABLE 2: TRIMMING OF SHEEP CARCASSES

Statistics for sets of 25 total aerobic counts (cfu/cm^2), coliform counts (cfu/100 cm^2) or *Escherichia coli* counts (cfu/100 cm^2) obtained from randomly selected sites on the hindquarters of sheep carcasses selected at random from those entering or leaving a hindquarters trimming operation.

Count	Stage of the operation	Statistics				
		$\bar{x}$	s	no	log A	N
Total	Before	3.19	0.73	0	3.79	4.97
	After	3.15	0.57	0	3.52	4.75
Coliform	Before	1.67	1.43	2	4.00	4.68
	After	1.85	1.43	2	4.20	4.43
E. coli	Before	1.18	1.55	8	3.93	4.43
	After	1.43	1.60	5	4.37	4.51

$\bar{x}$=mean log; s=standard deviation; no=samples without bacteria; log A=log mean; N=log total number recovered.

Vacuum cleaning

Vacuum cleaning operations are usually applied to areas of the carcass where contamination of the meat with hair is common. With beef carcasses those would typically be relatively small areas of the rear hocks and the crutch, where hairs are frequently deposited during cutting open of the skin. Vacuuming operations on those areas on beef carcasses are usually performed between or immediately after the hindquarters skinning operations.

With traditional skinning of carcasses suspended by the rear legs, as opposed to inverted dressing of sheep carcasses (Bell and Hathaway, 1996), the hindquarters of sheep carcasses are commonly contaminated with hairs. Therefore, vacuum cleaning has commonly been applied to the whole of the hindquarters of sheep carcasses.

Operations for the vacuum cleaning of the hocks of beef carcasses (Table 3) or the hindquarters of sheep carcasses (Table 4) were examined. For each operation, the sets of total aerobic counts before or after the treatment, and the two sets of coliform counts were similar, while the values for log A or N for the set of *E. coli* counts obtained after the treatment were about 0.5 log less than the values obtained before the treatment. Thus, as might be expected, some bacteria are apparently removed along with hairs and particles of dirt from areas of carcasses subjected to vacuum cleaning. However, the numbers of bacteria removed are too few to be of any hygienic consequence.

TABLE 3: VACUUM CLEANING OF BEEF CARCASSES

Statistics for sets of 25 total aerobic counts (cfu/cm^2), coliform counts (cfu/100 cm^2) or *Escherichia coli* counts (cfu/100 cm^2) obtained from randomly selected sites on the rear hocks of beef carcasses selected at random from the carcasses entering or leaving an operations for vacuum cleaning the hocks.

Count	Stage of the process	Statistics				
		$\bar{x}$	s	no	log A	N
Total	Before	3.45	0.49	0	3.72	5.08
	After	3.23	0.43	0	3.43	4.75
Coliform	Before	1.77	0.84	0	2.58	3.84
	After	0.98	1.09	6	2.34	3.40
E. coli	Before	1.56	0.85	0	2.40	3.69
	After	0.77	0.94	6	1.78	2.98

$\bar{x}$=mean log; s=standard deviation; no=samples without bacteria; log A=log mean; N=log total number recovered.

TABLE 4: VACUUM CLEANING OF SHEEP CARCASSES

Statistics for sets of 25 total aerobic counts (cfu/cm^2), coliform counts (cfu/100 cm^2) or *Escherichia coli* counts (cfu/100 cm^2) obtained from randomly selected sites on the hindquarters of sheep carcasses selected at random from the carcasses entering or leaving an operation for vacuum cleaning the hindquarters.

Count	Stages of the operation	Statistics				
		$\bar{x}$	s	no	log A	N
Total	Before	3.37	0.56	0	3.73	5.01
	After	3.30	0.47	0	3.58	4.94
Coliform	Before	1.89	1.43	3	4.25	4.70
	After	1.81	1.39	3	4.05	4.79
E. coli	Before	1.45	1.45	5	3.85	4.40
	After	1.15	1.37	7	3.29	3.92

$\bar{x}$=mean log; s=standard deviation; no=samples without bacteria; log A=log mean; N=log total number recovered.

Vacuum-hot water cleaning

Vacuum-hot water cleaning of beef carcasses is performed with an apparatus which delivers a stream of water of a temperature above 82°C onto the carcass surface from a nozzle within a vacuum head which is operated with a line vacuum greater that 175 mm Hg. Steam of a temperature above 82°C is delivered to a jacket which surrounds the head, or onto the head from nozzles above and below the head. The mouth of the vacuum head measures approximately 10 x 5 cm.

Vacuum-steam cleaning is applied to relatively small areas of beef carcasses which are prone to being visibly contaminated during specific dressing operations soon after each of the contaminating operations.

Three such vacuum-hot water cleaning operations in a beef carcass dressing process were examined. The data from the operations for vacuum-hot water cleaning the crotch (Table 5) or anal (Table 6) areas indicated that the treatments were ineffective for removing bacteria. However, the data from the operation for vacuum-hot water cleaning an area of the brisket indicated marginal reduction in bacterial numbers as a result of the treatment (Table 7).

Vacuum-hot water cleaning has been substituted for vacuum cleaning of the hindquarters of sheep carcasses. For that purpose a vacuum /hot water /steam head of similar construction to that used for beef carcasses, but with a mouth that measures approximately 5 x 1 cm is used. The smaller head is needed to effectively apply the vacuum head to the sharper contours of sheep carcasses, which are small compared with beef carcasses. The equivalent sets of microbiological data before or after the cleaning operation were similar (Table 8), indicating that there was no microbiological effect of the cleaning operation.

Destruction of bacteria by the heating of carcasses surfaces requires that the surface temperature be raised above 80°C for at least 10 s (Gill and Badoni, 1997). Thus, large reductions of bacterial numbers have been observed when a vacuum-hot water cleaning head was held at one point on each treated carcass for about 15 s (Kochevar *et al.*, 1997). However, in commercial practice, the head is moved over an area of a least several hundred cm^2 during a period of no more than 20 s. Thus, no part of the carcass surface is heated for more than second or two. Consequently, there is no substantial destruction of bacteria by heating.

Any reduction in bacterial numbers is then largely a result of their physical removal. It appear that the vacuum-hot water head is little or no more effective than vacuuming alone for removing bacteria from meat, although the former treatment may be superior for removing some forms of visible contamination. Thus, if vacuuming alone is considered adequate for removing visible contamination from some part of carcasses, nothing would be gained by replacing vacuuming by a vacuum-hot water cleaning treatment.

TABLE 5: VACUUM-HOT WATER CLEANING OF BEEF CARCASSES OPERATION I

Statistics for sets of 25 total aerobic points (cfu/cm^2), coliform counts (cfu/100 cm^2) or *Escherichia coli* counts (cm/100 cm^2) obtained from randomly selected sites on the crotches of beef carcasses selected at random from the carcasses entering or leaving an operation for vacuum-hot water cleaning of the crotch area.

Count	Stage of the operation	Statistics				
		$\bar{x}$	s	no	log A	N
Total	Before	3.76	0.65	0	4.25	5.50
	After	3.47	0.46	0	8.71	5.17
Coliform	Before	3.05	1.27	0	4.89	5.01
	After	2.30	1.27	0	4.17	4.80
E. coli	Before	2.78	1.17	0	4.36	4.90
	After	2.06	1.39	0	4.28	4.84

$\bar{x}$=mean log; s =standard deviation; no =samples without bacteria; log A=log mean; N=log total number recovered.

TABLE 6: VACUUM HOT-WATER CLEANING OF BEEF CARCASSES OPERATION II

Statistics for sets of 25 total aerobic points (cfu/cm^2), coliform counts (cfu/100 cm^2) or *Escherichia coli* counts (cfu/100 cm^2) obtained from a site on the anal area of beef carcasses which were selected at random from the carcasses entering or leaving an operation for vacuum-hot water cleaning of the anal area.

Count	Stage of the operation	Statistics				
		$\bar{x}$	s	no	log A	N
Total	Before	2.62	0.52	0	2.94	4.22
	After	2.19	0.65	0	2.68	4.20
Coliform	Before	0.38	0.79	7	1.10	2.81
	After	0.18	0.87	14	1.06	2.46
E. coli	Before	0.21	0.78	10	0.90	2.51
	After	0.01	0.76	14	0.68	2.29

$\bar{x}$=mean log; s=standard deviation; no=samples without bacteria; log A=log mean; N=log total number recovered.

TABLE 7. VACUUM-HOT WATER CLEANING OF BEEF CARCASSES OPERATION III

Statistics for sets of 25 total aerobic points (cfu/cm^2), coliform counts (cfu/100 cm^2) or *Escherichia coli* counts (cm/100 cm^2) obtained from randomly selected sites on the briskets of beef carcasses selected at random from the carcasses entering or leaving an operation for vacuum-hot water cleaning the brisket area.

Count	Stage of the operation	Statistics				
		$\bar{x}$	s	no	log A	N
Total	Before	4.03	0.63	0	4.48	5.78
	After	3.70	0.40	0	3.88	5.28
Coliform	Before	1.62	0.92	1	2.66	3.79
	After	1.12	0.84	2	1.93	3.20
E. coli	Before	1.24	1.10	4	2.63	3.71
	After	0.61	0.97	7	1.70	3.05

$\bar{x}$=mean log; s=standard deviation; no=samples without bacteria; log A=log mean; N=log total number recovered.

TABLE 8: VACUUM-HOT WATER CLEANING OF SHEEP CARCASSES

Statistics for sets of 25 total aerobic points (cfu/cm^2), coliform counts (cfu/100 cm^2) or *Escherichia coli* counts (cm/100 cm^2) obtained from randomly selected sites on the hindquarters of sheep carcasses selected at random from the carcasses entering or leaving an operation for vacuum-hot water cleaning of the hindquarters.

Count	Stage of the operation	Statistics				
		$\bar{x}$	s	no	log A	N
Total	Before	3.01	0.52	0	3.32	4.67
	After	2.80	0.64	0	3.27	4.66
Coliform	Before	2.18	1.39	1	4.39	4.60
	After	2.00	1.42	1	4.33	4.91
E. coli	Before	1.88	1.46	3	4.32	4.52
	After	1.31	1.59	6	4.21	4.70

$\bar{x}$=mean log; s=standard deviation; no=samples without bacteria; log A=log mean; N=log total number recovered.

Conclusions

As vacuum-cleaning, vacuum-hot water cleaning or trimming at the end of a dressing process are equally ineffective for removing bacteria from carcasses, operations involving such treatments should not be regarded as Critical Control Points. Instead, they should be regarded as Quality Control Points, for assurance that the appearances of carcasses meet with customers' requirements. With regard to that quality the principal customer is a meat inspecting authority, but that should not be allowed to confuse the matters of the visible cleanliness of carcasses and meat safety.

In the absence of any safety consideration, a treatment for removing visible contamination can be selected with consideration of only cost and convenience, provide that the treatment removes the visible contamination. In general, cleaning treatments would seem preferable to trimming, as the former operations involve no loss of salable meat. Capital and running costs for vacuum cleaning equipment are less than those for vacuum-hot water cleaning. Thus, nothing would be gained by substituting vacuum-hot water cleaning for vacuum cleaning where the latter treatment was performing satisfactorily as, for example, in the removal of hairs. Conversely, substitution of trimming at the end of the line by vacuum or vacuum-hot water cleaning treatments would seem worth investigating in many processes.

The inutility of trimming at the end of the line for improving the microbiological condition of carcasses does not necessarily imply that all trimming is similarly ineffective. It is possible that trimming applied immediately after a known contaminating operation irrespective of visible contamination at the affected site, or immediate trimming of carcass affected by a misprocessing event, such as spillage of gut contents, may be effective means of controlling microbiological contamination. Those uses of trimming require investigation.

References

Bell, R.G. and Hathaway, S.C. 1996. The hygienic efficiency of conventional and inverted lamb dressing systems. J. Appl. Bacteriol. 81, 225-234.

Biss, M.E. and Hathaway, S.C. 1995. Microbiological and visible contamination of lamb carcasses according to preslaughter presentation status: implications for HACCP. J. Food Prot. 58: 776-783.

Biss, M.E. and Hathaway, S.C. 1996. Microbiological contamination of ovine carcasses associated with the presence of wool and faecal material. J. Appl. Bacteriol. 81: 594-600.

Dorsa, W.J., Cutter, C.N., Siragusa, G.R. and Koohmaraie, M. (1996) Microbiol decontamination of beef and sheep carcasses by steam, hot water spray washes, and a steam-vacuum sanitizer. J. Food Prot. 59: 127-135.

Gill, C.O. and Badoni, M. 1997. The hygienic and organoleptic quantities of ground beef prepared from manufacturing beef pasteurized by immersion in hot water. Meat Sci. 46: 67-75.

Gill, C.O. and Baker, L.M. 1997. Assessment of the hygienic performance of a sheep carcass dressing process. J. Food Prot. (in press).

Gill, C.O. and Bryant, J. 1997. Decontamination of carcasses by vacuum-hot water cleaning and steam pasteurizing during routine operations at a beef packing plant. Meat Sci. (in press).

Gill, C.O., Badoni, M. and Jones, T. 1996. Hygienic effects of trimming and washing operations in a beef-carcass-dressing process. J. Food Prot. 59: 666-669.

Gill, C.O., Bedard, D. and Jones, T. 1997. The decontaminating performance of a commercial apparatus for pasteurizing polished pig carcasses. Food Microbiol. 14: 71-79.

Hardin, M.D., Acuff, G.R., Lucia, L.M., Omar, J.S. and Savell, J.W. (1995) Comparisons of methods for decontamination from beef carcass surfaces. J. Food Prot. 58: 368-374.

Kochevar, S.L. Sofos, J. N. Bolin, J. D. and Smith, G.C. 1997. Steam vacuuming as a pre-evisceration intervention to decontaminate beef carcasses. J. Food Prot. 60: 107-113.

MFSC. 1992. Microbiology and Food Safety Committee of the (US) National Food Processors Association. HACCP and Total Quality Management-winning concepts for the 90's: a review. J. Food Prot. 55: 459-462.

Phebus, R.K. Nutsch, A.L., Schafer, D.E., Wilson, R.C., Riemann, M.J. Leising, J.D., Kastner, C.L., Wolf, J.R. and Prasai, R.K. 1997. Comparison of steam pasteurization and other methods for reduction of pathogens on surfaces of freshly slaughtered beef. J. Food Prot. 60: 476-484.

USDA 1995. U.S. Department of Agriculture, Food Safety and Inspection Service. Comparison of methods for achieving the zero tolerance standard for fecal, ingesta, and milk contamination of beef carcasses: notice of conference. Fed. Regist. 60: 49553-49564.

USDA 1996. U.S. Department of Agriculture, Food Safety and Inspection Service. Pathogen reduction; hazard analysis and critical control point (HACCP) system; final rule. Fed. Regist. 61: 38805-38989.