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Bacteriological status of beef carcasses at a commercial abattoir before and after slaughterline improvements

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SUMMARY

The bacteriological status of beef carcasses was monitored at a commercial abattoir before and after two stages of modernization to the beef slaughterline which included changing from cradle dressing to dressing on an overhead rail, and the introduction of hot water spray cleaning of carcasses. Although small significant ($P < 0{\cdot}05$) differences in bacterial count occurred among carcass sites within modernization stages, significant visit within stage variation and stage × site interactions prevented any significant change in overall count being observed among stages and carcass sites. Principal components analysis revealed small changes in the distribution of bacterial numbers on the sites sampled.

INTRODUCTION

It has long been assumed that structural changes and slaughter practices designed to improve hygiene within an abattoir will result in lower numbers of bacteria being transferred to the carcass. The lack of systematic data to support this assumption was noted by Ingram & Roberts (1976). Large and costly modifications to abattoirs may be undertaken on the basis of preconceived ideas rather than evidence that the desired effects would be obtained (Roberts, 1980). Increasingly the role of the slaughterman, and his supervision, are being demonstrated to be key factors in the production of bacteriologically acceptable carcasses.

Although modern working conditions alone are no guarantee of good hygiene they can be important in creating the correct attitude to hygiene among slaughterhouse personnel. Unfortunately changes in working conditions and structural improvements in UK abattoirs are usually undertaken on a piecemeal basis with an inevitable compromise with existing facilities.

When costly improvements were proposed for an old, medium-sized, United Kingdom abattoir, including modernizing the beef slaughterline in two stages, management kindly agreed that we might investigate the effect on the bacteriological status of the beef carcasses.

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MATERIALS AND METHODS

Original beef slaughterline

Base stage (cradle dressing, cold water (CC)). After stunning by captive bolt and exsanguination, the carcasses were flayed manually on a cradle in the horizontal position, the final removal of the hide taking place as the carcasses were hoisted to an overhead rail suspended by the hind legs. The brisket was opened by handsaw while the carcass was on the cradle. Evisceration was performed in the partially hoisted position, the guts and entrails being collected in a barrow for transportation to the gut room. The carcasses were split with an electrically powered chine saw and after trimming were washed down with cold mains water from a hosepipe fitted with a trigger nozzle. No pithing rod was used.

Stage 1 improvements (rail dressing, cold water (RC))

Slaughter and exsanguination procedures remained the same but flaying and evisceration was performed with carcasses suspended by their rear legs and hanging vertically. New equipment included an electrically powered brisket saw, pneumatically operated hoof shears and high level platforms for the slaughterman flaying and trimming the hindquarters of the carcasses. A variable height pneumatically powered platform for the chine saw operator was installed as were several hot water hand washing and knife sanitizing facilities.

A new gut room was constructed within the existing slaughterhall and a gut-chute was installed with a powered lift to transfer the guts through a hatch onto new stainless steel tables where they were cleaned.

A general improvement to the building was made by treating the old cracked wall tiles with a thick coat of water-impervious plasticized white paint to a height of 10 ft. The corners of walls in the slaughterhall were protected to a height of 10 ft with sheet aluminium, bolted onto the walls and sealed with mastic material. The old flagstone slaughterhall floor was retained with some improvements to the drainage. Various old disused entrances were bricked up and new doors fitted to those that were retained. All existing ironwork was repainted.

Stage 2 improvements (rail dressing, hot water (RH))

A new carcass spray-cleaning system was installed comprising four hand operated Schermer SM3 sprayheads situated at various stages on the slaughterline. These were operated at up to 80 p.s.i. line pressure giving an impact temperature of 45 °C with a flow rate of *c.* 34 l/min.

Bacteriological sampling

On the original slaughterline, (stage CC), and after each of the two improvement stages (stages 1 (RC) and 2 (RH)), ten carcasses were each sampled immediately prior to chilling on four sites, neck, brisket, forerib and round medial surface (i.e. sites 1, 2, 3 and 9 in Roberts *et al.* 1980) on six separate occasions. Sampling consisted of swabbing a 50 cm^2 area on each site first with cotton wool swab moistened with bacteriological diluent comprising 0·85 % (w/v) NaCl + 0·1 % (w/v) peptone from a 10 ml volume into which it was taken and then with a dry swab which was placed in the same container.

Bacterial counts

Total viable counts (TVCs) were made on Standard Plate Count Agar (Oxoid CM463) incubated at 30 °C for 3 days using the loop/tile method described by Hudson, Roberts & Whelehan (1983).

Calculation of results

Results were calculated using counts at two or more dilutions with weighting for dilution as described by Farmiloe *et al.* (1954).

Statistical analysis

The bacterial counts were transformed to logarithms to the base 10 and a split plot design analysis of variance performed with the visits forming the whole plots and the ten carcasses sampled at each visit forming the sub-plots.

In addition principal components analysis was used on the means of the 10 carcasses samples at each of the 18 visits, treating sites as variables. This analysis is capable of revealing changing patterns of hygiene amongst the data not previously suspected (Whelehan, Hudson & Roberts, 1986).

RESULTS

The mean count at each stage of modernization for each carcass site and visit are shown in Table 1 and the analysis of variance in Table 2. The overall mean count for the original slaughterline was 3·60 ($\log_{10}$ bacteria/cm^2), and for stages 1 (RC) and 2 (RH) modifications 3·57 and 3·76. There were no overall significant differences ($P > 0{\cdot}05$) between stages because of significant visit within stage variation, i.e. at any stage, counts varied on different visits.

There was also a highly significant interaction between stages and sites, which prevented any significant differences between sites (Table 1, last column).

There were small but significant differences between stages at sites 1 and 9 (neck and round medial). At site 1 (neck) the original slaughterline gave lower bacterial counts than either stages 1 (RC) or 2 (RH) while at site 9 the stage 1 (RC) line yielded the lowest counts and the stage 2 (RH) line the highest. Site 2 (brisket) was significantly the most contaminated on the original and stage 1 (RC) line but not significantly different from site 9 at stage 2 (RH).

The results of the principal components analysis are summarized in Table 3. The first three principal components accounted for 92 % of the total variation among the 18 visits, with the second and third accounting for a substantial proportion. The first principal component had loadings of the same sign indicating that it represented variation due to overall dirtiness as measured by a weighted sum of the counts at the four sites. As expected from the results of the analysis of variance this principal component offered no separation of the three stages of abattoir development (plot not shown, for conciseness).

The second and third principal components thus represented patterns of variation in hygiene which were independent of overall dirtiness. The principal components scores of the 18 visits together with the site loadings are presented in Fig. 1 and indicate good discrimination among the three stages (original (CC), stage

Table 1. *Bacterial counts on beef carcasses on six visits to a commercial abattoir at each stage of modernization*

		Visit						Site
	Site	1	2	3	4	5	6	mean
Original slaughterline (CC)	1	3·79*	3·32	3·13	2·98	3·03	2·88	3·19a
	2	4·03	4·21	4·43	3·82	4·28	4·26	4·17cd
	3	3·49	3·12	3·69	3·59	3·94	3·47	3·55b
	9	3·44	3·33	3·72	3·43	3·47	3·60	3·50b
Visit mean		3·69	3·50	3·74	3·46	3·68	3·55	3·60
Stage 1 (RC)	1	3·91	4·19	3·77	3·14	3·30	3·40	3·62bc
	2	4·03	4·29	3·91	3·61	4·09	3·93	3·98d
	3	3·60	4·17	3·68	3·32	3·48	3·59	3·64b
	9	3·26	3·73	3·25	2·58	2·69	2·66	3·03a
Visit mean		3·70	4·10	3·66	3·16	3·39	3·39	3·57
Stage 2 (RH)	1	3·79	3·59	3·57	3·34	4·17	3·59	3·68c
	2	4·40	4·29	3·71	3·66	3·78	3·75	3·93d
	3	3·98	3·37	3·09	2·86	3·93	3·44	3·44b
	9	3·91	3·92	3·57	4·18	4·02	4·23	3·97d
Visit mean		4·02	3·79	3·48	3·51	3·98	3·76	3·76
Site mean across visits	1	3·83	3·70	3·49	3·16	3·50	3·29	3·49
	2	4·16	4·26	4·02	3·70	4·05	3·98	4·03
	3	3·69	3·55	3·49	3·26	3·78	3·50	3·55
	9	3·53	3·66	3·51	3·40	3·40	3·50	3·50
Overall visit mean		3·80	3·80	3·63	3·38	3·68	3·57	3·64

S.E.D. among sites = 0·11; S.E.D. among stages = 0·17; L.S.D. = S.E.D. × 1·98.
* $\log_{10}$ bacteria/cm². Each tabulated value is the mean for 10 carcasses per visit.
Significance ($P < 0·05$), different letters within the column of site means.

Table 2. *Analysis of variance*

Source	D.F.	*ms*	*F* ratio	*P*
Whole plots				
Stage	2	2·44	1·08	N.S.
Residual	15	2·26		
Sub-plots				
Site	3	12·04	33·57	N.S.
Stage × site	6	5·60	15·62	< 0·001
Residual	693	0·36		

N.S., not significant; D.F., degrees of freedom.

Table 3. *Principal component loadings*

	Principal component		
Site	1	2	3
1	−0·48	0·54	−0·47
2	−0·49	−0·57	0·40
3	−0·64	−0·26	−0·32
9	−0·33	0·56	0·72
% Variance accounted for	42·1	28·7	21·3

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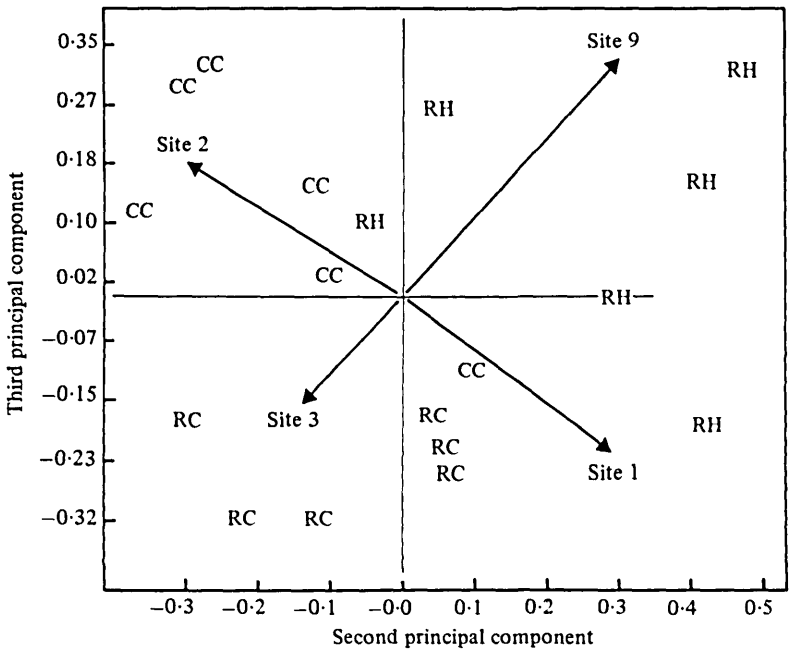

Fig. 1. Beef carcass sampling site scores for the second and third principal components in relation to stages of improvement. CC, Cradle dressing, cold water spray (the original slaughterline); RC, rail dressing, cold water spray (stage 1); RH, rail dressing, hot water spray (stage 2).

1 (RC) and stage 2 (RH)), with the six visits to each stage fairly well grouped, although less well for stage 2 (RH). Therefore, we can conclude that although no overall differences in hygiene were evident among the three stages, each stage was characterized by a particular pattern of hygiene at the four sites.

The visits to the original line, with one exception, clustered in the top left of Figure 1, indicating relatively high counts at site 2 coupled with low counts at site 1. The stage 1 (RC) visits are well grouped towards the bottom left of Figure 1 indicating high counts at sites 3 and to a lesser extent at site 1, but in particular, low counts at site 9. The six stage 2 (RH) visits are more scattered but are generally associated with high counts at site 9 and to a less extent at site 1, coupled with low counts at site 3.

There are relatively few surveys of the bacteriological status of commercial beef carcasses using comparable methodologies. Although numbers in this survey are somewhat higher than those found in some surveys (Nottingham, Penney & Harrison, 1973; Nottingham & Wyborn, 1974; Roberts, MacFie & Hudson, 1980; Johanson *et al.* 1983; Whelehan, Hudson & Roberts, 1986) they were lower than those from a 'single-phase' (horizontal) slaughter system and similar to those of a conveyor line (vertical) system (De Zutter & Van Hoof, 1982).

The problems of comparing bacterial counts from different abattoirs were illustrated by Roberts *et al.* (1984) where abattoir × site and abattoir × visit interactions made valid comparisons between abattoirs invalid.

It is evident that the extensive modernization undertaken at this abattoir did not result in any marked improvement in the bacteriological status of the

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carcasses, although the throughput of animals increased by *c.* 20% (from *c.* 18 to 22 per hour) with the same number of slaughtermen employed.

The value of principal components analysis in detecting relatively small changes in distribution of bacterial numbers on the sites sampled is demonstrated.

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