Research Note

Microbiological Conditions of Sheep Carcasses from Conventional or Inverted Dressing Processes†

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ABSTRACT

At a small abattoir, 25 sheep carcasses were dressed conventionally, with the carcass suspended by the rear legs, and 25 carcasses were dressed while inverted, with the carcasses suspended by the forelegs. Two swab samples were obtained from randomly selected sites on each carcass, and total aerobic, coliform, and Escherichia coli counts were enumerated for each sample. Each type of count was arranged in two sets of 25 counts for each type of dressing process, and a log mean number and/or log total number recovered was calculated for each set of counts. The log mean number of total aerobic counts for one set of counts from carcasses dressed while inverted was less than the corresponding log mean numbers for both sets from the conventionally dressed carcasses and the other set from the carcasses dressed while inverted, and differed from them by about 0.7 log units. The coliforms recovered from carcasses were largely E. coli. The log total numbers of coliform or E. coli counts recovered from carcasses dressed while inverted were about 1.5 log units less than the corresponding log total numbers recovered from conventionally dressed carcasses. Those data indicate that the substitution of inverted for conventional dressing might serve to reduce the numbers of E. coli on sheep carcasses by reducing the microbiological contamination of the hindquarters but that the general microbiological condition of the carcasses would be little improved unless some means of preventing or removing contamination of the forequarters was also used.

In conventional carcass dressing processes, sheep carcasses are shackled by first one then the other hind leg while the unshackled hind leg and rump are skinned. Subsequently, the carcasses are suspended from a gambrel by both rear legs for skinning of the forequarters and evisceration (7). An alternative type of process, referred to as inverted dressing, involves the carcasses being skinned while suspended by the forelegs, with suspension by the rear legs being adopted only after skinning is completed (2). The inverted dressing process was devised as a means of reducing the labor required for skinning by pulling the hide from the rump and both hind legs in a single, brief operation rather than cutting the skin from those areas in two protracted operations as in conventional dressing (14). A second benefit perceived to arise from the inverted hindquarters skinning operation was reduced contamination of the carcass (15). Most of the visible and microbiological contamination on sheep carcasses is deposited on the meat during the skinning operations, both by direct contact of the outer surface of the pelt with the meat and indirectly by hands and equipment alternately contacting the surface of the pelt and the meat (5). Since both direct and indirect contacts between the surface of the hide and the meat of the hindquarters are largely avoided in the inverted dressing process, visible contamination of the hindquarters is less than with conventional dressing (2).

Although there is no consistent relationship between the extents of visible and microbiological contamination (3, 6), the minimal handling of the hindquarters during inverted skinning could be expected to result in the microbiological condition of inverted-dressed carcasses being generally better than that of conventionally dressed ones. In the only reported study of that matter, sheep carcasses from two conventional and an inverted commercial carcass dressing processes were examined (2). The findings were that the total aerobic counts were, as expected, less on the inverted dressed than on the conventionally dressed carcasses but that the numbers of Escherichia coli were higher on the former than on the latter carcasses. If it is indeed the case that inverted dressing results in carcasses being more heavily contaminated with E. coli and, presumably, associated enteric pathogens (18) than conventionally dressed carcasses, then inverted dressing can hardly be recommended as a means of improving the safety of sheep meats. However, further data relating to the matter seem to be required to make a decision as to whether or not such a general conclusion is warranted. Therefore, the microbiological conditions of sheep carcasses dressed at a single plant by a conventional or an inverted dressing process were examined.

MATERIALS AND METHODS

Carcass dressing. Fifty sheep were slaughtered at a small packing plant that is part of a research facility but that is inspected.
by the national meat inspecting authorities, with much of the meat produced being dispatched for normal commercial uses. Cattle and pigs are regularly slaughtered at the plant, and other species are slaughtered occasionally (10). The plant staff members were, therefore, familiar with but relatively unpracticed in the conventional dressing of sheep carcasses and were unfamiliar with inverted dressing before the study.

The sheep were slaughtered on 3 days, with 17 being slaughtered on the first and last and 16 on the second of those days. The carcasses were dressed conventionally on the first and inverted on the third day, with half the carcasses being dressed conventionally and half inverted on the second day. For the conventional dressing process, the procedures used followed the practices usual at North American commercial plants, which have been described previously (7). For inverted dressing, the procedures detailed in publications from the Meat Industry Research Institute of New Zealand were followed (1, 16).

**Sampling of carcasses and enumeration of bacteria.** After the final wash in the dressing process, each carcass was allowed to drain for 10 min before a sample was obtained from each of two sites selected at random from a grid that specifies 43 areas on one side of a sheep carcass surface. Each sample was obtained by swabbing an undelimitated area of approximately 100 cm² with a sterile gauze swab, as described previously (8). Each swab was processed separately for the enumeration of total aerobic, coliform, and E. coli counts by hydrophobic grid membrane filtration procedures, with detection of the organisms at levels of 1 CFU/cm², 1 CFU/100 cm², and 1 CFU/100 cm², respectively, as previously described (9).

**Analysis of data.** The three counts from each of the two swabs from each carcass were randomly assigned to separated groups to obtain two sets of 25 counts for each of the total aerobic, coliform, and E. coli counts recovered from conventionally dressed carcasses and two sets of 25 counts for each of those organisms recovered from carcasses that were dressed inverted.

All bacterial counts were transformed to \( \log_{10} \) values. For each set of counts, when bacteria were recovered from 20 or more of 25 samples, values for the mean \( \log(x) \) and standard deviation (SD) were calculated on the assumption of a log-normal distribution of the counts (4). In the calculation of \( \log \) and SD for sets of coliform and E. coli counts, a log value of -0.5/100 cm² was assumed for each sample in which coliforms or E. coli were not detected at the level of 1 CFU/100 cm².

For sets for which \( \log \) and SD were calculated, a value for the log of the arithmetic mean (log A) was calculated from the formula \( \log A = \bar{x} + \ln 10 \cdot SD^2/2 \) (13). Also, for such sets, the differences in mean logs that were each weighted with respect to the variance of the mean were separated by the multiple comparison Rynan-Einot-Gabriel-Welsh multiple F test option of the general linear model procedure in SAS, version 6 (SAS Institute Inc., Cary, N.C.). A value for the log of the total number of bacteria recovered (n) was calculated for each set of counts by summing the counts in each set and obtaining the log of the sum. Values for \( x, \) SD, and \( n \) were calculated using Microsoft Excel Version 4, statistical functions (Microsoft Corp., Redmond, Wash.).

**RESULTS**

The sheep presented for slaughter all had long and dirty but dry fleeces. A total aerobic count was obtained from every sample from the carcasses (Table 1). The values for the log mean numbers of total aerobic counts were similar for the two sets of counts from conventionally dressed carcasses and one of the sets from carcasses dressed while inverted, but the log mean value for the second set of total aerobic counts from carcasses dressed while inverted was more than 0.5 log units less than the other log mean values for total aerobic counts. The values for the log total numbers of total aerobic counts were similar for one of the sets from conventionally dressed carcasses and one of the sets from carcasses dressed while inverted. The value for the log total numbers of total aerobic counts for the other set of counts from conventionally dressed carcasses was about 0.5 log units more, and the corresponding value for the

<table>
<thead>
<tr>
<th>Count</th>
<th>Dressing process</th>
<th>Set</th>
<th>( \bar{x} )</th>
<th>SD</th>
<th>No.</th>
<th>Log A</th>
<th>n</th>
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<td>0</td>
<td>2.96</td>
<td>4.64&lt;sup&gt;c&lt;/sup&gt;</td>
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<td></td>
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<td>0</td>
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<td>2.03 A</td>
<td>0.81</td>
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<td>1.31</td>
<td>4</td>
<td>3.24</td>
<td>4.50&lt;sup&gt;d&lt;/sup&gt;</td>
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<td></td>
<td></td>
<td>2</td>
<td>1.12 B</td>
<td>1.36</td>
<td>4</td>
<td>3.24</td>
<td>4.42&lt;sup&gt;d&lt;/sup&gt;</td>
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<td>—</td>
<td>9</td>
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<td>10</td>
<td>—</td>
<td>2.60&lt;sup&gt;d&lt;/sup&gt;</td>
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</table>

<sup>a</sup> \( \bar{x} \), mean of \( \log_{10} \) counts; SD, standard deviation of \( \log_{10} \) counts; No., number of samples in which bacteria were not detected; Log A, \( \log_{10} \) of the arithmetic mean; n, \( \log_{10} \) of the total number of bacteria recovered.

<sup>b</sup> Mean logs with the same letter are not significantly different (\( P > 0.05 \)).

<sup>c</sup> Recovered from 25 cm².

<sup>d</sup> Recovered from 2,500 cm².

<sup>e</sup> Insufficient data for calculation of the statistic.
FIGURE 1. Distributions of E. coli on sheep carcasses dressed conventionally (A) or while inverted (B). Each of the 50 samples from each type of carcass yielded no E. coli (○) or E. coli at log numbers/100 cm² between 0 and less than 1 (●), 1 and less than 2 (□), 2 and less than 3 (■), 3 and less than 4 (△), or 4 and less than 5 (▲).

other set of counts from carcasses dressed while inverted was about 0.5 log units less than the values for the similar pair. The values for the mean log numbers of total aerobic counts for the two sets of counts from conventionally dressed carcasses and one of the sets of counts from carcasses dressed while inverted were not significantly different (P > 0.05).

The incidences of coliform-positive samples allowed calculation of log mean values for both sets of coliform counts obtained from conventionally dressed carcasses but for neither of the sets of coliform counts obtained from carcasses dressed while inverted (Table 1). The corresponding values for the log mean numbers and the log total numbers of coliforms were the same or similar for the two sets of coliform counts from conventionally dressed carcasses. The log total numbers of coliforms for the sets of counts from carcasses dressed while inverted were similar and more than 1.5 log units less than the log total numbers for the sets of coliform counts from conventionally dressed carcasses.

The incidence of E. coli-positive samples did not allow the calculation of a log mean for any of the sets of counts (Table 1). The log total numbers of E. coli from conventionally dressed carcasses were similar among the sets. The log total numbers of E. coli from carcasses dressed while inverted were also similar among the sets, but those values were more than 1.5 log units less than the corresponding values for conventionally dressed carcasses.

The higher log total numbers of coliform and E. coli counts for sets of counts from conventionally dressed carcasses than from carcasses dressed while inverted were the result of the former sets of counts each including one or two log counts approaching or exceeding 4 log units, which were all recovered from sites on the hindquarters of carcasses, whereas all log values for coliform and E. coli counts obtained from carcasses dressed while inverted were less than 2.3 (Fig. 1).

DISCUSSION

The differences between the log mean numbers and/or the log total numbers of total aerobic counts recovered from carcasses dressed while inverted compared with conventionally dressed carcasses indicate that inverted dressing resulted in some small, microbiologically trivial reduction in the numbers of bacteria on carcasses. Such a conclusion is wholly compatible with inverted dressing being highly effective for controlling the microbiological contamination of the hindquarters. Extensive handling of the carcass is unavoidable during both inverted and conventional skinning of the neck and brisket and during conventional skinning of the hindquarters. Moreover, during those operations, the pelt tends to roll up toward the inner surface at cut edges to bring the outer surface of the pelt in contact with the meat (5). Thus, the neck, brisket, and hindquarters of the conventionally dressed carcass all tend to be similarly and heavily contaminated (12). If heavy contamination of the
hindquarters is prevented by inverted dressing, the area of the carcass surface that is heavily contaminated would, of course, be reduced; however, even if that reduction amounted to 50% of the total area of heavy contamination on the conventionally dressed carcass, the log number of bacteria on the carcass would be reduced by only about 0.3 log units. Such a reduction is trivial, since log numbers of bacteria that differ by less than 0.5 log units must be regarded as similar (8).

However, the reductions in the numbers of coliforms and E. coli on carcasses as a result of inverted dressing instead of conventional dressing were not trivial, because most of the coliforms, which were largely E. coli, were recovered from a few heavily contaminated sites on the hindquarters of conventionally dressed carcasses. Such contamination was not apparent at other parts of the conventionally dressed carcasses or on any part of the carcasses dressed while inverted. That is unsurprising, given that the fleece of the tail, crotch, and back legs is likely to be contaminated with more E. coli-bearing fecal material than is the fleece of other areas (17).

The findings of this and the previous study of the microbiological effects of inverted dressing (2) are agreeable with regard to the contamination of carcasses with total aerobic counts but contradictory with regard to the contamination of carcasses with E. coli. The contrary findings of the previous study seem to have arisen from the comparison of conventional dressing processes at two plants with an area of conventional dressing processes at two plants with an area of conventional dressing processes at two plants with the findings of this study. The data are probably insufficient for deciding the differences in the conditions of hindquarters with respect to E. coli contamination.

Therefore, the findings of the previous study do not seem to detract from the conclusions indicated by this study, which are that the substitution of inverted for conventional dressing might result in reduction of the numbers of E. coli deposited on carcasses but that the general microbiological condition of the meat would be little improved unless some means of preventing or removing contamination of the foreparts of the carcass was also used.

ACKNOWLEDGMENTS

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REFERENCES