In-Plant Evaluation of a Prototype Carcass Cleaning and Sanitizing Unit 1,2

M. E. ANDERSON3, R. T. MARSHALL4*, W. C. STRINGER4 and H. D. NAUMANN4

U.S. Department of Agriculture, Science and Education Administration, 113 Eckles Hall, University of Missouri, Columbia, Missouri 65211 and Food Science and Nutrition Department, University of Missouri-Columbia, Columbia, Missouri 65211

(Received for publication September 20, 1979)

ABSTRACT

An experimental cleaning and sanitizing unit was used in cleaning and sanitizing (3.0% acetic acid) beef carcasses. It cleaned the carcasses sufficiently that they would pass the Acceptable Quality Level test of the Food Safety and Quality Service, U.S. Department of Agriculture. The sanitizing unit reduced the microbial population on the surface of the meat by an initial 1.49 logs; the difference between washed and washed and sanitized carcasses after 1 week (168 h) was 0.92 log. A slight gray cast developed within the top 1 mm of fat almost immediately after the acid was applied. Sensory panel members detected no adverse effects on the lean portion of steaks from sanitized carcasses. However, they detected a slight off-flavor in treated fat.

Washing of beef carcasses immediately after slaughter is a standard industry practice; however, washed carcasses usually are not sanitized. Patterson (9) reported a reduction in log bacterial counts associated with application of chlorinated water. Other researchers have reported studies on sanitizing beef surfaces at breaking plants and under laboratory conditions (2,5,7,8,11). Eustace et al. (6) showed that treatment with dilute acetic acid extended the storage life of vacuum-packaged lamb carcasses by at least 4 weeks. Our studies (1) on cleaning and sanitizing surfaces of beef plate meat have indicated that the operation should be conducted in two steps because each step has a different objective. The objective of washing a carcass is to remove foreign material such as hair and dirt particles, as required by the U.S. Department of Agriculture, Food Safety and Quality Service, whereas the objective of a sanitizing procedure is to reduce the microbial population and maintain the reduced level.

The study reported here was designed to determine the effect of washing and sanitizing carcasses of beef on reduction in microbial populations, removal of foreign material, water uptake, shrinkage, carcass yield and the pH and titratable acidity of surface tissue under production conditions.

1 Contribution from USDA-SEA-AR in cooperation with the University of Missouri Experiment Station. Journal Series No. 8378
2 Mention of a trade name or proprietary product does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or the University of Missouri Experiment Station and does not imply its approval to the exclusion of other products that may also be suitable.
3 U.S. Department of Agriculture.
4 Department of Food Science and Nutrition.

MATERIALS AND METHODS

Materials

Forty-eight half carcasses were either (a) washed with tap water (40 C) or (b) washed with tap water (40 C) and sanitized with acetic acid (3.0% w/v, 40 C). Materials for the aerobic plate count were used (10).

The experimental beef carcass washing and sanitizing unit consisted of washing and sanitizing chambers, spray bars, a spray bar oscillation device, several no. 50XX nozzles (Spraying Systems Co.) and a high-pressure water pump.

Method

An operational process chart of procedures followed in this study to collect data on microbial populations, foreign material, carcass weight, and Acceptable Quality Level (AQL) (4) is shown in Fig. 1. Microbial populations on the meat surfaces were enumerated by the swab method (10). Surfaces of meat samples were swabbed as described in Fig. 1 and reference 10. Aerobic plate counts were made according to the Compendium of Methods (10), except that incubation was at 28 C for 72 h. Each half carcass was randomly selected for either of the following two treatments: (a) water wash (pressure, 26 kg/cm2; volume, 284 L/min) or (b) water wash (same conditions as in a) and sanitizing with a 3.0% acetic acid solution (pressure, 14 kg/cm2; volume, 95 L/min). The speed of carcass travel through the washing and sanitizing units was 10 cm/sec. Nozzles of the washing unit were oriented to primarily clean those areas expected to have high concentrations of foreign matter and bone dust. Thus the nozzles were aimed primarily at the hock, shank and sawed bone of the carcass. Nozzles on the sanitizing unit were oriented to distribute acetic acid uniformly on the carcass.

The pH was determined on 10 g of surface meat (about 1.0-mm deep) which was blended for 3 min with 50 ml of sterile distilled water. To measure titratable acidity, 10 g of surface meat (approximately 1-mm deep) was blended with 50 ml of distilled water for 3 min. The extract was decanted, and the residue was blended for an additional 2 min in 50 ml of water. Liquid was again decanted, and the residue, blender and funnel used to collect the extract were washed with an additional 50 ml of water. The insoluble material was discarded. Five drops of phenolphthalein were added to the extract and it was titrated with 0.1 N NaOH. Acidity was calculated as percentage of lactic acid, based on the weight of the meat.

Shrinkage, carcass yield and water absorbed were determined by the following method:

Shrinkage (%)= Weight before treatment—weight 24 h after treatment

\[
\text{Weight before treatment} - \text{weight 24 h after treatment} \times 100
\]

Carcass yield (%)= Weight of dressed half carcass

\[
\text{Weight of dressed half carcass} \times 100
\]

\[
\text{Weight before treatment}
\]

Water absorbed (lb)= Weight of half carcass before treatment — weight of half carcass 4 min after treatment

\[
\text{Weight of half carcass before treatment} - \text{weight of half carcass 4 min after treatment}
\]
An inspection showed an average of 3.2 and 2.6 minor defects, as defined by FSQS (4) for each washed and each washed and sanitized half carcass, respectively. No major or critical defects, as defined by FSQS (4), were noted on any of the 48 half carcasses. However, the number of defects on half carcasses that were washed and sanitized was significantly lower (P < 0.05) than on carcasses that were washed, only. This finding indicated that the sanitizing solution removed additional foreign material from the meat.

Changes in log counts of microorganisms for three time periods (0, 24, and 168 h) after treatment and for five locations (round, brisket, clod, H-bone, and neck) as affected by washing or washing and sanitizing are shown in Table 1. When differences in logarithms in counts made immediately after treatment were averaged over all locations, washing reduced counts only about 0.17 log, or 5.3%, whereas sanitizing reduced counts an additional 1.49 logs, or 96.8%.

Samples taken 24 h after half carcasses were washed had lower counts than those taken immediately; however, each mean count of the washed and sanitized samples was higher after 24 h of storage than immediately after the treatment. Of particular interest were the large increases in counts on the clod and neck. These are areas of high moisture concentration, and we suggest that the acetic acid was more dilute in these areas than on the round or the aitch bone. Also, the rougher texture of the meat surfaces in these areas probably protected microorganisms from exposure to effective doses of the sanitizer. Washing of the beef carcass initially reduced the mean microbial population (averaged over all locations) by only 0.17 log. In carefully controlled laboratory cleaning studies (7), we obtained reductions of up to 1.0 log (90%) by washing. In the laboratory studies, wash water was sprayed uniformly over relatively small flat surfaces of meat. In the present studies, the need to direct much of the wash water toward carcass parts most likely to be dirty may have caused the lower efficiency of removal of the microorganisms.

The differences in microbial counts among locations for 0, 24 and 168 h after washing only were 0.25, 0.72, and 1.49 log, respectively. These differences were significant at the 0.05 level and indicate that an operation process chart for evaluation of carcass cleaning and sanitizing unit is necessary.

RESULTS AND DISCUSSION

Counts of foreign particles in four specific areas of the carcass, viz., (a) hock, (b) aitch bone, (c) brisket and (d) shank showed that after washing, the average number of particles on the hock and aitch bone increased by 0.2 and 1.2, whereas the average number on the shank and brisket decreased by 4 and 15.8, respectively. Counts of foreign particles after both washing and sanitizing indicated average increases of 2.2 and 2.8 particles for the hock and aitch bone respectively, and average decreases of 2.7 and 5.6 for the shank and brisket, respectively. Increases in particles on the hock and aitch bone likely resulted from foreign particles washing down the meat. In the present studies, we obtained reductions of up to 1.0 log (90%) by washing. In the laboratory studies, wash water was sprayed uniformly over relatively small flat surfaces of meat. In the present studies, the need to direct much of the wash water toward carcass parts most likely to be dirty may have caused the lower efficiency of removal of the microorganisms.

The differences in microbial counts among locations for 0, 24 and 168 h after washing only were 0.25, 0.72, and 1.49 log, respectively. These differences were significant at the 0.05 level and indicate that an operation process chart for evaluation of carcass cleaning and sanitizing unit is necessary.

TABLE 1. Changes in log counts of microorganisms for three time periods after treatment (0, 24, and 168 h) for each washed and each washed and sanitized half carcass, respectively.

<table>
<thead>
<tr>
<th>Location of sample</th>
<th>WS</th>
<th>WS and SAN</th>
<th>WS</th>
<th>WS and SAN</th>
<th>WS</th>
<th>WS and SAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Round</td>
<td>-0.07X</td>
<td>-1.60X</td>
<td>-0.29X</td>
<td>-1.33X</td>
<td>0.54X</td>
<td>-0.13X</td>
</tr>
<tr>
<td>Brisket</td>
<td>-0.12X</td>
<td>-1.65X</td>
<td>-0.51X</td>
<td>-1.56X</td>
<td>0.27X</td>
<td>-0.23X</td>
</tr>
<tr>
<td>Clod</td>
<td>-0.05X</td>
<td>-1.58X</td>
<td>-0.11X</td>
<td>-0.88X</td>
<td>0.87X</td>
<td>0.56X</td>
</tr>
<tr>
<td>Aitch bone</td>
<td>-0.27X</td>
<td>-1.89X</td>
<td>-0.53X</td>
<td>-1.78X</td>
<td>0.83X</td>
<td>0.62X</td>
</tr>
<tr>
<td>Neck</td>
<td>-0.32X</td>
<td>-1.58X</td>
<td>-0.14X</td>
<td>-0.88X</td>
<td>1.30X</td>
<td>-0.17X</td>
</tr>
<tr>
<td>Mean</td>
<td>-0.17X</td>
<td>-1.66X</td>
<td>-0.37X</td>
<td>-1.29X</td>
<td>0.76X</td>
<td>-0.163X</td>
</tr>
</tbody>
</table>

Log counts for the following periods of time after treatment (h)

An inspection showed an average of 3.2 and 2.6 minor defects, as defined by FSQS (4) for each washed and each washed and sanitized half carcass, respectively. No major or critical defects, as defined by FSQS (4), were noted on any of the 48 half carcasses. However, the number of defects on half carcasses that were washed and sanitized was significantly lower (P < 0.05) than on carcasses that were washed, only. This finding indicated that the sanitizing solution removed additional foreign material from the meat.

Changes in log counts of microorganisms for three time periods (0, 24, and 168 h) after treatment and for five locations (round, brisket, clod, H-bone, and neck) as affected by washing or washing and sanitizing are shown in Table 1. When differences in logarithms in counts made immediately after treatment were averaged over all locations, washing reduced counts only about 0.17 log, or 5.3%, whereas sanitizing reduced counts an additional 1.49 logs, or 96.8%.

Samples taken 24 h after half carcasses were washed had lower counts than those taken immediately; however, each mean count of the washed and sanitized samples was higher after 24 h of storage than immediately after the treatment. Of particular interest were the large increases in counts on the clod and neck. These are areas of high moisture concentration, and we suggest that the acetic acid was more dilute in these areas than on the round or the aitch bone. Also, the rougher texture of the meat surfaces in these areas probably protected microorganisms from exposure to effective doses of the sanitizer.

Washing of the beef carcass initially reduced the mean microbial population (averaged over all locations) by only 0.17 log. In carefully controlled laboratory cleaning studies (7), we obtained reductions of up to 1.0 log (90%) by washing. In the laboratory studies, wash water was sprayed uniformly over relatively small flat surfaces of meat. In the present studies, the need to direct much of the wash water toward carcass parts most likely to be dirty may have caused the lower efficiency of removal of the microorganisms.

The differences in microbial counts among locations for 0, 24 and 168 h after washing only were 0.25, 0.72, and 1.49 log, respectively. These differences were significant at the 0.05 level and indicate that an operation process chart for evaluation of carcass cleaning and sanitizing unit is necessary.
and 1.03 logs, respectively; respective differences of counts of samples that were both washed and sanitized were 0.3, 0.9, and 1.38 logs. Thus the differences increased considerably with storage time.

Half carcasses absorbed an average of 0.45 kg of water during washing, whereas those that were both washed and sanitized absorbed 0.75 kg of water. However, the difference was not significant (P < 0.05). Shrinkage averaged 1.68 kg for the washed half carcasses and 1.46 kg for the washed and sanitized half carcasses; the percent shrinkage was 1.14 and 0.98, respectively. Again, differences were not significant. Likewise, carcass yield (dressing percentage) was unaffected by the treatments. The initial assumption that the high pressure of the wash water that might have been added during washing or the shrinkage after 24 h. The data on shrinkage after 24 h indicated that any water absorbed or the shrinkage after 24 h. However, surfaces of muscles sanitized with acetic acid decreased in acetic acid concentrations, in turn, would reduce the bactericidal effect of the acid. Washing of the carcass appeared to cause no significant effect (P < 0.05) on titratable acidity.

The sensory panel detected no differences in the flavor of exterior muscle tissue are shown in Table 2. As expected, no difference (P < 0.05) was noted in the pH of the two groups of samples before treatment. Also, washing did not affect the pH of the meat surface. However, surfaces of muscles sanitized with acetic acid dropped in pH from a mean of 5.69 to 5.25 immediately after sanitizing and then increased to 5.38 after 24 h. Lowering of the pH of the surface by the acetic acid solution and the presence of the unionized acid were thought to be responsible for reductions in aerobic plate counts. After the meat was washed and sanitized with acetic acid, titratable acidity rose to 0.146 % and then decreased to 0.131 % after 24 h (Table 3). This result indicated that some of the acetic acid molecules may have volatilized, diffused into the tissue or been buffered by the meat, or all three, during the 24-h storage period (3.3 C). The decrease in acetic acid concentrations, in turn, would reduce the bactericidal effect of the acid. Washing of the carcass appeared to cause no significant effect (P < 0.05) on titratable acidity.

The sensory panel detected no differences in the flavor of the lean portion of the steaks due to treatment. However, they indicated that the taste of fat from treated steaks was different from that of untreated fat (P < 0.05); they described the treated fat as having a slight off-flavor.

In addition to the flavor defect observed in the fat, color was also affected by the acetic acid sanitizers. A slight gray cast developed within the top 1 mm of fat almost immediately after the acid was applied. This study showed that the experimental beef carcass cleaning and sanitizing unit cleaned the carcasses adequately to pass the AQL test of the Food Safety and Quality Service, U.S. Department of Agriculture.

### TABLE 2. Effect of washing or washing and sanitizing on pH of surface muscle of half carcasses of beef.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>pH of surface muscle&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Before</th>
<th>Immediately after</th>
<th>After 24 h</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washing</td>
<td>5.78&lt;sup&gt;x&lt;/sup&gt;</td>
<td>5.75&lt;sup&gt;x&lt;/sup&gt;</td>
<td>5.70&lt;sup&gt;x&lt;/sup&gt;</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>Washing and sanitizing</td>
<td>5.69&lt;sup&gt;x&lt;/sup&gt;</td>
<td>5.25&lt;sup&gt;y&lt;/sup&gt;</td>
<td>5.28&lt;sup&gt;y&lt;/sup&gt;</td>
<td>0.44</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>0.09</td>
<td>0.50</td>
<td>0.32</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Each value represents 24 observations.

<sup>x</sup>Values with different superscripts in each column are significantly different (P < 0.05).

### TABLE 3. Effect of washing or washing and sanitizing of half carcasses of beef on titratable acidity of meat surface (depth 10 mm).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Titratable acidity&lt;sup&gt;a,b&lt;/sup&gt;</th>
<th>Before</th>
<th>Immediately after</th>
<th>After 24 h</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washing</td>
<td>0.144&lt;sup&gt;x&lt;/sup&gt;</td>
<td>0.146&lt;sup&gt;y&lt;/sup&gt;</td>
<td>0.1158</td>
<td>0.012</td>
<td></td>
</tr>
<tr>
<td>Washing and sanitizing</td>
<td>0.145&lt;sup&gt;x&lt;/sup&gt;</td>
<td>0.146&lt;sup&gt;y&lt;/sup&gt;</td>
<td>0.1319</td>
<td>0.042</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>0.00</td>
<td>0.04</td>
<td>0.016</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Each value represents 24 observations.

<sup>b</sup>Indicator-phenolphthalein; titrant-0.1 N NaOH.

<sup>x</sup>Values with different superscripts in each column are significantly different (P < 0.05).