Research Notes

Aerobic Bacteria and Solids in a Three-Tank, Two-Pass, Counterflow Scaler

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ABSTRACT Scald water and whole carcass rinse samples were collected on 9 different d in a commercial broiler processing plant operating adjacent lines that processed birds from the same flock simultaneously. A conventional, single-tank, two-pass scaler was installed on one line and the other line had a three-tank, two-pass, counterflow scaler in which water mixed across the two lines of carcasses within each tank. Water samples from the turn around point in each tank were analyzed for aerobic bacteria and suspended solids. At the same time that water samples were taken, six carcasses were removed from the processing line immediately after feather removal and rinsed in 100 mL of phosphate-buffered saline; recovered rinse solution was analyzed for aerobic bacteria using a most probable number procedure. Estimated numbers of aerobic bacteria were significantly reduced in the third tank of the counterflow scaler compared to the second tank, or compared to the single tank of the conventional scaler. Despite the differences in aerobic bacteria between scald tanks, numbers of aerobic bacteria in carcass rinses were not affected by scaler design. Organic and total solids were significantly reduced in the third tank of the counterflow scaler compared to the first and second tanks, and in the third tank of the counterflow scaler compared to the conventional scaler. Solids in the third (final) tank of the counterflow scaler were reduced by about 70% compared to the conventional scaler.

(Key words: scalding, aerobic bacteria, solids, carcass rinses, broiler)

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INTRODUCTION

In counterflow or countercurrent scalding of poultry, net flows of carcasses and scald water are in opposite directions, so that carcasses on the shackle line generally move into progressively cleaner water. Using a standard industrial formula for mixing of liquids, a computer program by Veerkamp (1989) assumed typical scailer volumes and flow rates and calculated a reduction of bacterial numbers in scald water in the last tank of a counterflow scaler. Pilot plant studies using a multiple-tank scalding system that incorporated bacteria in a fecal slurry confirmed significant reductions in numbers of bacteria suspended in scald water (Veerkamp et al., 1991). In a commercial setting, Veerkamp and Heemskerk (1992) found a reduction in numbers of Enterobacteriaceae in the water of the last tank of a counterflow scaler. Pilot plant studies using a multiple-tank scalding system that incorporated bacteria in a fecal slurry confirmed significant reductions in numbers of bacteria suspended in scald water (Veerkamp et al., 1991). In a commercial setting, Veerkamp and Heemskerk (1992) found a reduction in numbers of Enterobacteriaceae in the water of the last tank of a three-tank, two-pass counterflow scaler compared to a single-tank scaler previously operating in the same processing plant.

A counterflow scaler with a postscald washer reduced aerobic bacteria and Enterobacteriaceae counts in rinses of pre-evisceration and postchill carcasses compared to rinses of carcasses from a conventional scaler previously operating in the same plant (James et al., 1992). A study sponsored by the National Broiler Council (Waldroup et al., 1992) also demonstrated a reduction in aerobic plate counts in carcass rinses after six modifications in processing, including counterflow scalding, were introduced in five poultry processing plants. Some plants also experienced a reduction in numbers and incidence of salmonellae and Campylobacter in carcass rinses, but it was impossible to attribute all of the difference to scalding because of the introduction of multiple changes in processing practices and equipment. Waldroup et al. (1993) sampled conventional and one-pass, counterflow scalers operating on adjacent processing lines. Aerobic plate count, coliforms, and Escherichia coli were significantly reduced in water dripping off carcasses leaving the counterflow scaler compared to the conventional scaler, but there were no differences in bacterial counts of carcass rinses after evisceration or after chilling. No water samples were taken directly from the scaler in that study.

The amount of suspended material in scald water (usually 2 to 8 g of total solids/L in conventional

Abbreviation Key: MPN = most probable number.
scalders) has been interpreted as an indication of how effectively carcasses are being cleaned during scalding (Humphrey, 1981; Humphrey et al., 1981; Shackelford et al., 1992). No information is available for suspended solids in multiple tank scalder, but there can be visible differences in the water and foam in the different tanks of a multiple-tank scalder. The purpose of the present experiment was to compare bacterial numbers and suspended solids in scald water in a three-tank, two-pass scalder vs a conventional, single-tank, two-pass scalder operating simultaneously on another slaughter line in the same plant.

**MATERIALS AND METHODS**

On 9 different d, scald water samples were taken from two adjacent slaughter lines, one operating with a single-tank, two pass scalder and the other with a three-tank, two-pass scalder with countercurrent water flow. Both scalders were assembled from sections that were originally manufactured by the same company, but the processor had introduced modifications such as agitation by compressed air rather than by electric pumps. Water mixed between the two lines of carcasses in the two-pass tanks in both scalders, so the counterflow scalder was counterflow only between tanks. The processing plant was operating two 8-h shifts; samples were taken 3 h after the start of the second shift. At the turn around point in each two-pass tank (Figure 1), 250 mL of scald water was collected aseptically at a depth of approximately 5 cm and transferred to a sealable sterile beaker. The sealed beakers were immediately placed in a bucket containing crushed ice for transportation to the laboratory. Target water temperature in all scald tanks was 56.6 C (maintained by steam injection) with a scald time of approximately 2 min. Line speed was 140 carcasses per min with carcasses 15.2 cm apart. During the period that samples were taken, makeup water (about 200 mL per carcass) was being added at the exit of the last tank of the three-tank scalder, but there was no overflow. Water was added at multiple points to the conventional scalder, which was operating with a normal overflow.

On each sampling day, six carcasses were removed from the shackle line immediately after feather removal and before the washer. Carcasses were aseptically placed in plastic bags and transported to the laboratory for microbiological testing within 1 h. At the laboratory, 100 mL of phosphate-buffered saline (Cox et al., 1981) was added to each bag and the bags were shaken for 1 min using an automated shaker (Dickens et al., 1985). After shaking, carcasses were removed from the bags and the remaining rinse liquid was transferred to a sealable, sterile container.

A 1:10 initial dilution was prepared by transferring 1 mL of the rinse sample or the scald water sample to a 9-mL dilution blank containing nutrient broth^2 in 16 ×
The MPN of aerobic bacteria in scald water samples and in rinses of defeathered carcasses are presented in Table 1. The third tank of the three-tank, counterflow scalding had significantly lower numbers of aerobic bacteria than the single-tank control scalder (3.85 vs 4.96 log_{10} cfu/mL). Waldroup et al. (1993) reported significantly fewer aerobes, coliforms, and E. coli in water dripping from carcasses leaving a single-pass counterflow scalder, compared to carcasses from a conventional multiple-pass scalder. Sampling in the present experiment, however, was done at the turn-around point in each tank. The operating characteristics of two-pass tanks should be somewhat different with less of a counterflow effect compared to the single-pass tanks sampled by Waldroup et al. (1993). In a series of two-pass tanks, counterflow conditions exist only between the tanks, because water from both files of carcasses can mix together. In a single-pass design, counterflow conditions can exist at all points in a tank.

There were no differences in carcass bacteria counts between the two slaughter lines with different scalders. Waldroup et al. (1993) also reported no differences in bacterial populations in rinses of carcasses sampled after evisceration or after chilling. Following a change from conventional to counterflow scalding, numbers of aerobic bacteria were reduced on carcasses rinsed after chilling in the studies by James et al. (1992) and Waldroup et al. (1992), but both of those studies involved multiple changes in processing and did not

### RESULTS AND DISCUSSION

150 mm disposable culture tubes with slip cap closures. The initial dilution was mixed using a vortex mixer and 1 mL of the mixture was transferred to the next tube in the series. A single tube was inoculated at each dilution level. After incubation at 37 C for 48 h, the number of tubes showing turbidity was recorded for each sample. The most probable number (MPN) was determined using the MPN computer program provided by Hurley and Roscoe (1983).

Total and inorganic solids were determined for each water sample as described by Shackelford et al. (1992). After shaking the sample in the original container, duplicate 50-mL aliquots of scald water were pipetted into 100-mL crucibles that had previously been dried for 18 to 24 h in a forced air oven, cooled in a desiccator, and weighed. Scald water samples were then dried for 4 h in a forced air oven at 103 C, cooled in a desiccator, and weighed. Scald water samples were then dried for 18 to 24 h in a forced air oven, cooled in a desiccator, and weighed to determine total solids. Crucibles were then placed in a muffle furnace at 550 C overnight. The following day crucibles were cooled in a desicator before weighing to determine inorganic solids content of the original water sample. Organic solids content was determined by difference.

Data were analyzed using ANOVA in a random block design in which blocks were sampling days (SAS Institute, 1987). The tank by day and scald by day interactions were used as the error terms to test for differences between tanks and between scalders designs, respectively. Bacterial numbers and suspended solids in the various tanks were tested against the last tank of the multiple-tank scalding using orthogonal contrasts.

### TABLE 1. Mean most probable number (log_{10} MPN ± SEM) estimates of aerobic bacteria in water samples (per milliliter) from each tank of a three-tank, two-pass, counterflow scalder and from a one-tank, two-pass scalder (control) and from whole carcass rinses of New York-dressed carcasses sampled immediately after defeathering (per carcass)

<table>
<thead>
<tr>
<th>Scaler type</th>
<th>Tank</th>
<th>Aerobic bacteria</th>
<th>P &gt; F1</th>
<th>Aerobic bacteria on picked carcasses</th>
<th>P &gt; F2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(per mL of water)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Counterflow</td>
<td>1</td>
<td>4.61 ± 0.36</td>
<td>0.1598</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>5.07 ± 0.44</td>
<td>0.0290</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3.85 ± 0.38</td>
<td></td>
<td>7.77 ± 0.18</td>
<td>0.85</td>
</tr>
<tr>
<td>Control</td>
<td>1</td>
<td>4.96 ± 0.41</td>
<td>0.0455</td>
<td>7.72 ± 0.20</td>
<td></td>
</tr>
</tbody>
</table>

1Probability that mean is different from value for Tank 3, determined by orthogonal contrasts.

### TABLE 2. Inorganic, organic, and total suspended solids in water samples from each tank of a three-tank, two-pass, counterflow scalder and from a one-tank, two-pass scalder (control)

<table>
<thead>
<tr>
<th>Tank</th>
<th>n</th>
<th>Inorganic (g/L ± SEM) (P &gt; F)</th>
<th>Organic (g/L ± SEM) (P &gt; F)</th>
<th>Total (g/L ± SEM) (P &gt; F)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(P &gt; F1)</td>
<td>(P &gt; F1)</td>
<td>(P &gt; F1)</td>
</tr>
<tr>
<td>1</td>
<td>9</td>
<td>0.86 ± 0.19 0.0031</td>
<td>4.26 ± 0.55 0.0001</td>
<td>5.12 ± 0.70 0.0001</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td>0.52 ± 0.16 0.2086</td>
<td>1.95 ± 0.38 0.0361</td>
<td>2.46 ± 0.54 0.0505</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
<td>0.30 ± 0.14 0.0019</td>
<td>0.74 ± 0.16 0.0007</td>
<td>1.04 ± 0.29 0.0018</td>
</tr>
<tr>
<td>Con</td>
<td>9</td>
<td>0.62 ± 0.16 0.0733</td>
<td>2.83 ± 0.38 0.0007</td>
<td>3.46 ± 0.50 0.0018</td>
</tr>
</tbody>
</table>

1Probability of a significant difference from Tank 3.
compare different scalder designs operating simultaneously. Lillard et al. (1987) reported a 2 log reduction in aerobic bacteria in scald water treated with 0.5% acetic acid, but total aerobes were not different in rinses of feathered carcasses sampled immediately after scalding. Numbers of bacteria attached to feathers and skin after scalding may be sufficient to overwhelm any differences in numbers of bacteria picked up from scald water.

Inorganic, organic, and total solids in the scald water samples are shown in Table 2. The third tank of the counterflow scalder had significantly less organic and total solids suspended in the water compared to either the control scalder or to the first two tanks of the three-tank scalder. The difference in suspended solids may account for differences in appearance of water and foam in the different tanks during normal operation. Solids content of the scald water is in the range reported by Humphrey (1981), Humphrey et al. (1981), and Shackelford et al. (1992). Organic solids made up approximately 80% of total solids in the various tanks.

Results from this study agree with previous reports that counterflow scalding can reduce the number of bacteria in water in the final sections of the scalder. Significant reductions in suspended solids also confirm the cleaning or diluting effect reported for counterflow designs. Counterflow scalding alone, however, was not sufficient to reduce bacterial populations on defeathered carcasses, agreeing with the findings of Waldroup et al. (1993).

REFERENCES
