Effects of Hot Water Application After Defeathering on the Levels of Campylobacter, Coliform Bacteria, and Escherichia coli on Broiler Carcasses

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ABSTRACT Scalding has been found to lower the levels of Campylobacter on broiler carcasses. However, the numbers recovered from whole-carcass rinse samples increase following defeathering. This study was undertaken to examine the effect of a second scald applied after defeathering on microbial levels recovered from carcass rinses. Four treatments were evaluated: 1) immersion at 60 C for 28 s 30 min after defeathering, 2) immersion at 60 C for 28 s immediately after defeathering, 3) spray at 73 C for 20 s 30 min after defeathering, and 4) spray at 71 C for 20 s immediately after defeathering. As reported earlier, a significant increase in Campylobacter counts per mL whole carcass rinse was noted after carcasses were defeathered. However, when applied 30 min after defeathering, neither the immersion nor the spray second scald treatments lowered the Campylobacter counts. Likewise, neither treatment had any affect on Escherichia coli or coliform bacteria counts, even though total counts were slightly reduced by the treatments. When the second scald treatment immediately followed defeathering, the same trends were observed. Campylobacter counts after the second scald remained at the postpick levels, as did counts for E. coli and coliform bacteria, but total plate counts were slightly reduced. Overall, it would appear that a postscald treatment gentle enough not to alter the carcass appearance or meat quality would not effectively lower Campylobacter, E. coli, or coliform bacteria counts.

(Key words: broiler, Campylobacter, hot water, processing, scald)

INTRODUCTION Campylobacter spp. (especially Campylobacter jejuni) are important human pathogens that cause foodborne illness ranging from self-limiting gastroenteritis to a number of severe sequelae. In 1998, 849 cases of campylobacteriosis were reported in Georgia (Georgia Department of Human Resources, 1999). Campylobacter has been associated with poultry carcasses and poultry products that have been processed further (White et al., 1997; Saleha et al., 1998). Campylobacter primarily flows into commercial processing facilities on and within live birds, and is distributed during the various processing procedures (Saleha et al., 1998).

Campylobacter populations of log_{10} 4.7 cfu/ml carcass rinse have been recovered from feathered carcasses prior to scald, with levels significantly reduced by as much as 3 log_{10} cfu per sample (carcass rinse or surface swab) as the carcasses move through the scald tank (Acuff et al., 1986; Izat et al., 1988; Berrang and Dickens, 2000). However, it has been noted that as carcasses exit the picker, the Campylobacter populations recovered from whole-carcass rinses (feathered carcasses before pick, featherless after pick) increase by 2 log_{10} cfu/ml to within 1 log_{10} cfu/ml of the prescald counts (Berrang and Dickens, 2000). These data agree with other published reports of an increase in bacterial counts due to defeathering found by sampling the skin surface with a swab technique (Acuff et al., 1986; Izat et al., 1988), indicating that the increase is not likely an artifact related to the presence or absence of feathers.

Hot water immersion treatments have been tested late in the processing line, after evisceration. Morrison and Fleet (1985) found that by immersing a prechill carcass in 60 C water for 10 min, the numbers of salmonellae can be lowered without adversely affecting carcass appearance. Cox et al. (1974) found that by immersion in water at 71 C for 1 min, total aerobic bacterial counts on carcasses could be lowered by almost 2 log_{10} cycles; however, this decrease came at the expense of a partially cooked appearance.

Dipping chicken parts in even hotter water for short times has also been tested. By using 95 C water for only 5 s, slight reductions in inoculated Salmonella, Staphylococcus aureus, and Listeria monocytogenes counts on chicken wings were noted (Rodriguez et al., 1996). However, organoleptic changes due to the treatment caused consumers to prefer the untreated controls.
A spray treatment may be easier to implement on a commercial processing line than a dip treatment. Research has been done to examine the efficacy of hot water sprays to improve the microbiological quality of meat. Hot water applied as a spray has been found to be effective in lowering bacterial populations inoculated onto beef carcasses (Castillo et al., 1998). Thomson et al. (1974) found that spraying broiler carcasses with 70°C water lowered overall aerobic bacterial counts by about 1 log$_{10}$ cfu per sample with only minimal adverse effect on carcass appearance.

The current study was undertaken to determine whether re-application of hot water following defeathering would lower microbial populations recovered from a whole-carcass rinse of a New York dressed broiler to a level comparable to that found directly following scalding, without visibly damaging carcass skin. The approach was to test application of hot water, by immersion or spray, on birds slaughtered commercially, and transported to the lab for a delayed rescald, and on birds slaughtered on site and subjected to an immediate rescald.

**MATERIALS AND METHODS**

**Delayed Rescald**

**Broilers and Processing.** All birds were grown in commercial houses, with feed removed approximately 12 h prior to slaughter. Carcasses were collected from the kill line of a commercial processing plant by removing them from the shackles and placing carcasses into individual sterile plastic bags. Sampling was timed such that all carcasses on any one sample day were from the same flock. On each sample day, eight carcasses were collected after scald before entering the picker, and another 16 were collected after being defeathered, immediately following the postpicker rinse. Carcasses were transported in insulated containers to the pilot processing plant and rehung on shackles within 30 min of collection. This 30-min period created the delay for the delayed rescald. The eight defeathered carcasses were sampled to provide a prepick point of reference. Groups of eight defeathered carcasses were each treated to one of two rescald procedures (immersion or spray), and eight defeathered carcasses without a rescald treatment served as controls. Three replications (three blocks) were conducted for each rescald method, for a total of 24 samples prepick, 24 postpick control samples and 24 treated samples per rescald treatment.

**Rescald Treatments.** Preliminary experiments were conducted to determine rescald times and temperatures that would not cause excessive damage to skin or muscle of defeathered broiler carcasses. Rescald treatments tested in these trials were found to produce carcasses without damaged skin. Delayed immersion rescald treatments were conducted in a pilot plant scald tank, which consisted of a single-pass, 8-ft section of a commercial scalding tank. Rescald water was maintained at 60 ± 1.5°C by a point value temperature controller. Commercial New York dressed carcasses were immersed in the tank for 28 s as the line moved through the scald tank. Delayed-spray rescald was done in a prototype spray scalder. Spray rescald water temperature was 79 ± 1°C in the reservoir that provided a 73 ± 1°C spray on the carcasses. Commercial New York dressed carcasses were exposed to the spray for 20 s as the line moved through the spray scalder cabinet. Temperatures were monitored by an electronic thermistor connected to an electronic thermometer with a digital display.

**Immediate Rescald**

**Broilers and Processing.** The second set of trials was undertaken in an effort to improve efficacy over that observed when rescald was applied with a 30-min delay after defeathering. Birds used in the immediate rescald experiments were grown in commercial broiler houses and subjected to approximately 12 h of feed withdrawal. Thirty-two birds on each sample day were removed from a single live-haul trailer at a commercial broiler processing plant. Birds were cooped and transported to the laboratory pilot processing plant facility. Three replications were conducted for each rescald method (immersion and spray); each replication was conducted on a different sample day. Eight birds at a time were stunned using 50 volts AC for 10 s, transferred to restraining cones, and slaughtered by severing the jugular vein and carotid artery. Birds were bled for 90 s before being placed in shackles. Because birds were handled in a pilot plant, it was practical to plug the cloaca of each carcass with a cotton plug (Musgrove et al., 1997) to prevent any excess variation in microbial loads due to the escape of colon contents during processing. Birds were scalded at 56°C for 120 s. Following scalding, four birds were removed as the prepick samples, and the remaining four birds proceeded through a five-bank picker. Control carcasses were removed for sampling after defeathering, whereas treated carcasses were subjected to one of the two rescald procedures (immersion or spray). Four runs were conducted on each sample day, systematically staggering treatments with controls to prevent possible time effects. Three replications (three blocks) were conducted for each rescald treatment, resulting in a total of 24 carcasses for each group.

**Rescald Treatments.** Immediate immersion rescald treatments were accomplished with a 240-L stainless steel tank. Four carcasses were aseptically removed from the overhead line as soon as they exited the picker and were rehung on shackles on a stainless steel bar. Carcasses were submerged for 28 s into water maintained at 60 ± 0.5°C. Temperature was controlled by adding steam to the water and circulating the water for uniformity. Temp-

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2Honeywell Corporation, Ft. Washington, PA 19034.
3Johnson Food Equipment Co., Kansas City, KS 66115.
4Stow Laboratories, Hudson, MA 01003.
perature was monitored with a digital thermometer equipped with a Type J thermocouple probe. Immediate spray recscald was performed in the same way as delayed spray recscald except for the temperature of the spray. Because the carcasses were moving directly from the cold water picker into the spray chamber, the temperature could not be maintained as high as for the delayed recscald experiment, for which birds were defeathered off site. Immediate spray recscald water was 77 ± 2°C in the reservoir, which provided a 70 ± 2°C spray on the carcasses. Carcasses were exposed to the spray for 20 s as the line moved through the spray scald cabinet.

**Sampling and Culture Methods**

Carcasses were sampled by a low-volume, whole-carcass rinse method whereby 100 mL of sterile distilled water was added to each bag containing a defeathered carcass (Cox et al., 1981). Feathered carcasses were rinsed in 300 mL distilled water. Carcasses were shaken for 1 min using a mechanical shaker (Dickens et al., 1985). Following the shaking step, each carcass was aseptically removed from the bag, and the remaining rinse fluid was decanted and used to make serial dilutions for culturing.

Serial dilutions were made in phosphate buffered saline, and *Campylobacter* was enumerated by plating in duplicate onto the surface of Campy-Cefex agar (Stern et al., 1992). One tenth mL was spread on the surface of each plate with a sterile plastic inoculating loop, after which plates were incubated at 42°C for 48 h in a microaerobic environment (5% O2, 10% CO2, 85% N2). Colony forming units characteristic of *Campylobacter* were counted. Each colony type counted as *Campylobacter* from each sample was confirmed as a member of the genus by examination of cellular morphology and motility on a wet mount under phase contrast microscopy. Each colony type was further characterized by a positive reaction on a latex agglutination test kit. Total aerobic bacterial populations were enumerated on plate count agar. Furthermore, coliform bacteria and *E. coli* counts remained unchanged at all three sample collection points. Counts of total aerobic bacteria were highest in the rinse from feathered carcasses (log10 4.8 cfu/ml), lower after the picker (log10 4.4), and even lower after the recscald (log10 3.9). Results of the 20-s spray at 73°C treatment 30 min after defeathering were similar to those measured with the immersion treatment (Table 2).

Results of the immersion recscald treatment immediately after defeathering are shown in Table 1. *Campylobacter* populations per mL of rinse increased significantly with defeathering (log10 1.5 vs. log10 3.9). However, an additional application of hot water by immersion had no effect on the *Campylobacter* population per mL of rinse. Furthermore, coliform bacteria and *E. coli* counts increases between the scalder and the end of the picker. An increase in *Campylobacter* population in the pickers of commercial plants has been reported (Izat et al., 1988; Berrang and Dickens, 2000), as has an increase in coliform bacteria and *E. coli* counts (Berrang and Dickens, 2000). The increase in counts noted in the current pilot plant study occurred on carcasses with plugged cloacae. This result suggests that colon leakage during picking is not the only source of the increase seen in bacteria recovered from carcass rinses after defeathering. The immediate recscald treatment did not affect *Campylobacter*, coliform bacteria, or *E. coli* counts recovered from rinses. Total aerobic bacteria counts recovered from rinses followed the same trend seen in the delayed recscald experiments, in which counts in samples collected after recscald were lower than those taken earlier. When the treatment was applied as a spray immediately after the picker, the results were very similar to those found when the treatment was applied as an immersion (Table 4).

Earlier attempts to lower microbial populations on broiler carcasses with hot water have suggested that within the parameters required to produce a quality prod-
### TABLE 1. Mean bacterial populations before and after a delayed (30 min after defeathering) immersion rescald treatment of 28 s at 60 ± 1°C

<table>
<thead>
<tr>
<th>Site</th>
<th>Campylobacter [log₁₀ cfu/ml (SEM) whole carcass rinse]</th>
<th>Coliform bacteria [log₁₀ cfu/ml (SEM) whole carcass rinse]</th>
<th>Escherichia coli [log₁₀ cfu/ml (SEM) whole carcass rinse]</th>
<th>Total aerobes [log₁₀ cfu/ml (SEM) whole carcass rinse]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postscald</td>
<td>1.5&lt;sup&gt;b&lt;/sup&gt; (0.17)</td>
<td>3.2&lt;sup&gt;a&lt;/sup&gt; (0.16)</td>
<td>2.3&lt;sup&gt;a&lt;/sup&gt; (0.15)</td>
<td>4.8&lt;sup&gt;a&lt;/sup&gt; (0.08)</td>
</tr>
<tr>
<td>Postpick</td>
<td>3.9&lt;sup&gt;a&lt;/sup&gt; (0.23)</td>
<td>3.3&lt;sup&gt;a&lt;/sup&gt; (0.14)</td>
<td>2.7&lt;sup&gt;a&lt;/sup&gt; (0.16)</td>
<td>4.4&lt;sup&gt;b&lt;/sup&gt; (0.10)</td>
</tr>
<tr>
<td>Postrescald</td>
<td>3.4&lt;sup&gt;a&lt;/sup&gt; (0.24)</td>
<td>3.0&lt;sup&gt;a&lt;/sup&gt; (0.19)</td>
<td>2.2&lt;sup&gt;a&lt;/sup&gt; (0.22)</td>
<td>3.9&lt;sup&gt;a&lt;/sup&gt; (0.11)</td>
</tr>
</tbody>
</table>

<sup>a</sup>–c Means within columns with no common superscript are significantly different (P < 0.05) by Tukey’s honest significant difference.

<sup>1</sup> Three replications, eight carcasses per replication (n = 24).

<sup>2</sup> Feathered carcasses.

### TABLE 2. Mean bacterial populations before and after a delayed (30 min after defeathering) spray rescald treatment of 20 s at 73 ± 1°C

<table>
<thead>
<tr>
<th>Site</th>
<th>Campylobacter [log₁₀ cfu/ml (SEM) whole carcass rinse]</th>
<th>Coliform bacteria [log₁₀ cfu/ml (SEM) whole carcass rinse]</th>
<th>Escherichia coli [log₁₀ cfu/ml (SEM) whole carcass rinse]</th>
<th>Total aerobes [log₁₀ cfu/ml (SEM) whole carcass rinse]</th>
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</thead>
<tbody>
<tr>
<td>Postscald</td>
<td>2.0&lt;sup&gt;b&lt;/sup&gt; (0.21)</td>
<td>3.5&lt;sup&gt;a&lt;/sup&gt; (0.10)</td>
<td>3.3&lt;sup&gt;a&lt;/sup&gt; (0.08)</td>
<td>4.9&lt;sup&gt;a&lt;/sup&gt; (0.11)</td>
</tr>
<tr>
<td>Postpick</td>
<td>4.0&lt;sup&gt;a&lt;/sup&gt; (0.17)</td>
<td>3.3&lt;sup&gt;a&lt;/sup&gt; (0.16)</td>
<td>3.0&lt;sup&gt;a&lt;/sup&gt; (0.13)</td>
<td>4.0&lt;sup&gt;b&lt;/sup&gt; (0.12)</td>
</tr>
<tr>
<td>Postrescald</td>
<td>3.9&lt;sup&gt;a&lt;/sup&gt; (0.24)</td>
<td>3.2&lt;sup&gt;a&lt;/sup&gt; (0.20)</td>
<td>2.9&lt;sup&gt;a&lt;/sup&gt; (0.19)</td>
<td>4.2&lt;sup&gt;b&lt;/sup&gt; (0.16)</td>
</tr>
</tbody>
</table>

<sup>a</sup>,<sup>b</sup> Means within columns with no common superscript are significantly different (P < 0.05) by Tukey’s honest significant difference.

<sup>1</sup> Three replications, eight carcasses per replication (n = 24).

<sup>2</sup> Feathered carcasses.

### TABLE 3. Mean bacterial populations recovered from broiler carcasses before and after an immediate immersion rescald treatment of 28 s at 60 ± 1°C

<table>
<thead>
<tr>
<th>Site</th>
<th>Campylobacter [log₁₀ cfu/ml (SEM) whole carcass rinse]</th>
<th>Coliform bacteria [log₁₀ cfu/ml (SEM) whole carcass rinse]</th>
<th>Escherichia coli [log₁₀ cfu/ml (SEM) whole carcass rinse]</th>
<th>Total aerobes [log₁₀ cfu/ml (SEM) whole carcass rinse]</th>
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</thead>
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<tr>
<td>Postscald&lt;sup&gt;1&lt;/sup&gt;</td>
<td>2.2&lt;sup&gt;b&lt;/sup&gt; (0.10)</td>
<td>2.0&lt;sup&gt;b&lt;/sup&gt; (0.13)</td>
<td>1.8&lt;sup&gt;b&lt;/sup&gt; (0.13)</td>
<td>4.7&lt;sup&gt;a&lt;/sup&gt; (0.05)</td>
</tr>
<tr>
<td>Postpick</td>
<td>3.3&lt;sup&gt;a&lt;/sup&gt; (0.14)</td>
<td>2.7&lt;sup&gt;a&lt;/sup&gt; (0.21)</td>
<td>2.4&lt;sup&gt;a&lt;/sup&gt; (0.25)</td>
<td>4.3&lt;sup&gt;b&lt;/sup&gt; (0.09)</td>
</tr>
<tr>
<td>Postrescald&lt;sup&gt;2&lt;/sup&gt;</td>
<td>3.3&lt;sup&gt;a&lt;/sup&gt; (0.14)</td>
<td>2.2&lt;sup&gt;a,b&lt;/sup&gt; (0.22)</td>
<td>1.9&lt;sup&gt;a,b&lt;/sup&gt; (0.22)</td>
<td>4.0&lt;sup&gt;a&lt;/sup&gt; (0.09)</td>
</tr>
</tbody>
</table>

<sup>a</sup>,<sup>b</sup> Means within columns with no common superscript are significantly different (P < 0.05) by Tukey’s honest significant difference.

<sup>1</sup>Pooled postscald (feathered carcass) counts from each replication, n = 16 per replication, three replications.

<sup>2</sup>n = 8 per replication, three replications.

### TABLE 4. Bacterial populations recovered from broiler carcasses before and after an immediate spray rescald treatment of 20 s at 70 ± 2°C

<table>
<thead>
<tr>
<th>Site</th>
<th>Campylobacter [log₁₀ cfu/ml (SEM) whole carcass rinse]</th>
<th>Coliform bacteria [log₁₀ cfu/ml (SEM) whole carcass rinse]</th>
<th>Escherichia coli [log₁₀ cfu/ml (SEM) whole carcass rinse]</th>
<th>Total aerobes [log₁₀ cfu/ml (SEM) whole carcass rinse]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postscald&lt;sup&gt;1&lt;/sup&gt;</td>
<td>1.9&lt;sup&gt;b&lt;/sup&gt; (0.12)</td>
<td>2.6&lt;sup&gt;b&lt;/sup&gt; (0.11)</td>
<td>2.1&lt;sup&gt;b&lt;/sup&gt; (0.13)</td>
<td>4.7&lt;sup&gt;a&lt;/sup&gt; (0.06)</td>
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<tr>
<td>Postpick</td>
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<td>2.9&lt;sup&gt;a&lt;/sup&gt; (0.21)</td>
<td>4.5&lt;sup&gt;b&lt;/sup&gt; (0.09)</td>
</tr>
<tr>
<td>Postrescald&lt;sup&gt;2&lt;/sup&gt;</td>
<td>2.5&lt;sup&gt;a&lt;/sup&gt; (0.23)</td>
<td>2.5&lt;sup&gt;a,b&lt;/sup&gt; (0.24)</td>
<td>2.2&lt;sup&gt;a,b&lt;/sup&gt; (0.26)</td>
<td>4.2&lt;sup&gt;b&lt;/sup&gt; (0.14)</td>
</tr>
</tbody>
</table>

<sup>a</sup>,<sup>b</sup> Means within columns with no common superscript are significantly different (P < 0.05) by Tukey’s honest significant difference.

<sup>1</sup>Pooled postscald (feathered carcass) counts from each replication, n = 16 per replication, three replications.

<sup>2</sup>n = 8 per replication, three replications.
uct, a short-time hot water treatment applied late in processing does not lower bacterial counts (Cox et al., 1974; Rodriguez et al., 1996). The scald tank significantly lowers the microbiological population recovered from rinses; however, these counts increase again as the carcass is defeathered. Cason et al. (1999) found that intermittent scalding and picking did not affect Campylobacter levels recovered from carcass rinses compared with those defeathered traditionally. It was hoped that the increase in Campylobacter populations observed as carcasses moved through the picker could be counteracted with a second scald, provided it was applied quickly after completion of defeathering. However, it would appear that this approach is insufficient without sacrificing product quality.

Although hot water may be a useful tool to control bacteria in broiler processing, application of water as a 28-s, 60 C dip or a 20-s, 73 C spray after the picker does not improve the microbiological quality of the product.

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REFERENCES


