Unheated Water in the First Tank of a Three-Tank Broiler Scalder

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ABSTRACT Scalding with unheated water in the first tank of a simulated three-tank scalder was tested to determine whether carcass bacteria, efficiency of feather removal, and cooked breast meat tenderness are affected as compared with carcasses scalded at the same temperature (57 C) in all tanks. This experiment was performed on 3 d using 6-wk-old broilers. On each day, eight birds per treatment were processed. During the first 40-s scalding period, one carcass was placed in approximately 24 C water. The other carcass was placed simultaneously in a scalder unit containing approximately 2,050 L of water at 57 C. Carcasses were then held out of the water for 15 s, after which both were placed for 40 s in opposite ends of the scalder containing water at 57 C. After the second scalding period, both carcasses were again removed from the water for 15 s, followed by another 40 s in the 57 C water. Total scald time was 2 min for each treatment. After picking, carcasses were rinsed with 200 mL of sterile 0.1% peptone water for 1 min. Aerobic bacteria and *Escherichia coli* were enumerated and incidence of salmonella was determined by standard methods. After rinsing, carcasses were eviscerated by hand and chilled for 30 min in ice slush. All carcasses were scored for the presence of feathers, and the appearance and condition of the skin were noted. Four hours postmortem, breast fillets were removed from carcasses and chilled overnight at 2 C. The next morning, breast fillets were cooked to an internal endpoint temperature of 75 to 80 C. Warner-Bratzler shear values were measured to determine tenderness. No differences were found in numbers of aerobic bacteria and *E. coli*, incidence of salmonellae, tenderness of cooked breast meat, or number of feathers left on carcasses.

(*Key words*: Aerobic bacteria, *Escherichia coli*, salmonellae, scalding, tenderness)

2001 Poultry Science 80:1643–1646

INTRODUCTION

During commercial slaughter of poultry, defeathering is accomplished by dipping carcasses into hot water immediately before feathers are picked by automatic equipment. Scalding affects feather follicles and allows removal of feathers with as much as 80% less force (Dickens and Shackelford, 1988), resulting in more complete feather removal and less skin damage than would occur without scalding. According to the Oxford English Dictionary, the first known use of the terms "scald" and "pick" in the same English sentence was in a cookbook that dates from about 1420, so the basic technology is not new.

There have been some relatively recent changes in scalder design, however. Installation of multiple-tank scalders and electronic controls in poultry processing plants permits management of scald water temperatures in ways that were difficult or impossible previously, but the feasibility of manipulating scald water temperature is uncertain. Some authorities have emphasized the need to keep temperatures constant throughout scalding (Parry, 1995), but the intention was probably to emphasize the importance of avoiding poor control that might result in sections of cooler water that might fail to transfer sufficient heat to affect the feather follicles. Supplemental scald tanks with higher water temperatures have been used to treat specific areas of carcasses such as necks and wings, where feathers may be more difficult to remove, so tanks with different water temperatures have been used in the poultry industry.

The need for complete and efficient feather removal requires some choices between contradictory effects on carcass and meat quality of scalded carcasses. Longer or hotter scalding may be better for feather removal, but scalding increases the toughness of cooked chicken and turkey breast meat with either longer scalding time (Koonz et al., 1954; Shannon et al., 1957; Klose et al., 1959; Pool et al., 1959) or higher temperatures (Shannon et al., 1957; Pool et al., 1959; Klose et al., 1959). Scalding temperature is more important than time of scalding according to Pool et al. (1954), but the opposite has also been reported (Shannon et al., 1957). The toughening effect of scalding

Received for publication February 5, 2001.

Accepted for publication July 2, 2001.

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Abbreviation Key: SPC = standard plate count; TT = tetrathionate broth with iodine.

is related to the depth to which the heat penetrated into muscles of chickens (Wise and Stadelman, 1959) and the peak temperature reached by the muscle during scalding (Wise and Stadelman, 1961).

Mechanical picking also increases the toughness of poultry breast meat (Pool et al., 1959; Klose et al., 1959). Longer or more vigorous picking may be required if lower scald temperatures or shorter scalding times are used and the feather follicles are not completely relaxed.

During scalding, large numbers of bacteria are removed from carcasses and many of them die in the hot scald water, but the process permits some bacterial cross-contamination between carcasses (Mulder and Dorresteijn, 1977; Mulder et al., 1978). Microbiological issues were not of great importance until relatively recently in the history of poultry scalding. Increasing scald water temperature to increase the death rate of bacteria may not be a management option, however, because higher temperatures also affect the skin's appearance, color, and cooking characteristics (Jones and Grey, 1989). The shelf life of hard-scalded carcasses is reduced, with increased numbers of spoilage bacteria isolated from carcasses at the upper ranges of scald temperatures (Clark, 1968). Any unnecessary heating of scald water also has an economic cost.

There have been anecdotal reports that some processing plants have tested different temperatures in the tanks of multiple-tank scalders. The purpose of the present experiment was to test the effects of lower-than-typical water temperature in the first tank of a three-tank scalder to determine whether carcass bacteria, efficiency of feather removal, and cooked breast meat tenderness are affected.

MATERIALS AND METHODS

This experiment was performed on 3 d, using 6-wk-old broilers obtained from the unloading area of a local processing plant and transported to the laboratory in coops. On each day, eight birds per treatment were processed. Birds were hung in shackles and stunned at 50 volts AC (30 mA) for 10 s, then bled in cones for 90 s after both carotid arteries were severed. Carcasses were handled in pairs during simulated three-tank scalding. During the first 40-s scalding period, one carcass was placed in approximately 24 C water in a 114-L plastic trash can. Compressed air was delivered through coiled, perforated copper tubing to achieve vigorous agitation of the water. The other carcass was placed simultaneously in a scalder unit containing approximately 2,050 L of water at 57 C. Carcasses were then held out of the water for 15 s, after which both were placed for 40 s in opposite ends of the scalder containing water at 57 C. After the second scalding period, both carcasses were again removed from the water for 15 s, followed by another 40 s in the 57 C water. Total scald time was 2 min for each carcass treatment, designated as CONTROL or LOWSCALD depending on the temperature of the first tank. Scalded carcasses were picked individually in an in-line commercial picker that was sprayed thoroughly with 80 C water between individual picking sessions to minimize transfer of bacteria between different carcasses. Previous experiments in which the picker was spray cleaned with hot water between treatments were successful in demonstrating treatment differences in numbers of carcass bacteria despite use of the same picking equipment (Musgrove et al., 1997).

After removal of heads and feet, the cloaca of each carcass was plugged with a tampon to prevent escape of intestinal contents during rinsing (Musgrove et al., 1997), thus eliminating intestinal sources of bacteria and isolating the effects of scalding and picking on bacteria on the exterior of the carcasses. Plugged carcasses were rinsed with 200 mL of sterile 0.1% peptone water for 1 min. Whole carcass rinses were obtained before evisceration, to determine carcass microbial load without any contamination that might occur during evisceration. Recovered rinse liquid was transferred to a sterile specimen cup and held on ice until microbiological analyses were conducted within 2 h. Serial dilutions were prepared in peptone water. Standard plate counts (SPC) were performed by plating serial dilutions on plate count agar[2] and incubating aerobically for 48 h at 35 C. Numbers of *E. coli* bacteria in the rinse samples were determined by inoculating duplicate dilutions on Petrifilm[3] and incubating 24 h at 35 C. All blue, gas-forming colonies were counted as *E. coli*. To determine incidence of salmonellae, 100 mL of the whole carcass rinse liquid was incubated in 100 mL of double-strength tetrathionate broth with iodine (TT) for 24 h at 35 C. One milliliter of that culture was transferred to 9 mL of TT and incubated for 24 h at 35 C. That culture was streaked onto XLT4 and BG sulfa agar plates that were incubated for 24 h at 35 C. Three suspect colonies were picked for biochemical identification using Triple Sugar Iron agar and Lysine Iron agar slants. Serological identification was performed by using Salmonella O antisera Poly A. A control *Salmonella typhimurium*, ST-10 culture was carried through each step as a positive control. Colony counts of bacteria were converted to $\log_{10}$ (cfu per milliliter of rinse) for statistical analysis.

After rinsing, carcasses were eviscerated by hand, wing banded, and chilled in a segmented paddle chiller containing ice slush turning at 4 rpm. Immediately after 30 min of chilling, carcasses were removed from the ice, bagged, and refrigerated at 2 C. When chilling was completed, all carcasses were examined and scored for the presence of feathers, and the appearance and condition of the skin were noted. A feather score for each carcass was determined by sorting carcasses into four groups ranging from well picked (score = 1) to poorly picked (score = 4), after which wing band numbers were recorded. Carcasses were rebagged and refrigerated at 2 C after scoring.

[2]Unless specified otherwise, media were from Difco, Detroit, MI 48232.

[3]*E. coli*/Coliform Count Plate, 3M Health Care, St. Paul, MN 55144-1000.

TABLE 1. Standard plate count, *E. coli*, and incidence of Salmonella in rinses of partially processed broiler carcasses after two scalding treatments

Scalding treatment[1]	n	Standard plate count[2]	*E. coli*[2]	Salmonella incidence
		$\log_{10}$(cfu/mL) ± SD		+/total
CONTROL	24	4.6 ± 0.7	3.0 ± 0.9	5/24
LOWSCALD	24	4.7 ± 0.6	2.9 ± 0.8	5/24

[1]All carcasses were scalded to simulate a three-tank scalder with a total scald time of 2 min: 40 s in the scald water, 15 s out of the water, 40 s in the water, 15 s out of the water, 40 s in the scald water. CONTROL scald water temperature was 57 C. LOWSCALD water temperature was 24 C during the first 40-s scalding, then 57 C in the last two 40-s intervals.

[2]Treatment means were not significantly different.

Four hours postmortem, breast fillets were removed from the carcasses, sealed in labeled plastic bags, and chilled overnight at 2 C. The next morning, breast fillets were cooked and sheared to determine tenderness. Breast fillets were cooked for 30 min in a water bath at 85 C with internal endpoint temperatures of 75 to 80 C. Cooked pieces were cooled in tap water for 15 min, then allowed to equilibrate to room temperature. One 1.9-cm-wide strip was cut from the anterior portion of both right and left breast fillets. The cuts were made parallel to the muscle fibers through the entire thickness of the fillets. Each strip was then sheared perpendicular to muscle fibers with a Warner-Bratzler shear apparatus[4] and the maximum force necessary to shear the piece was recorded. The shear values for the two breast halves were averaged to obtain a shear value for each broiler.

Statistical analysis was performed by using ANOVA in PROC GLM of SAS (SAS Institute, 1987). The data were analyzed in a random block design by using the treatment × day interaction as the error term, with significance defined as $P < 0.05$.

RESULTS AND DISCUSSION

In rinses of partially processed carcasses, there were no significant differences between SPC or *E. coli* counts in rinses from carcasses that were subjected to the CONTROL and LOWSCALD treatments (Table 1). Five carcasses of 24 were salmonellae positive in each treatment group. The lower temperature in the first tank had no effect on carcass microbiology as measured by SPC, *E. coli*, and incidence of salmonellae.

The washing action of scalding removes more bacteria from carcasses in the first tank compared to other tanks of a three-tank scalder (Cason et al., 2000). An industrial scald tank would have a much higher input of carcasses and resulting bacterial load than the tank used in the present experiment, and water at a lower temperature would allow increased survival of bacteria. Numbers of bacteria in scald water do not have a great effect on numbers of bacteria on defeathered carcasses, however. Bacteria in rinses of picked carcasses were not significantly different when acetic acid was used to lower the number of bacteria in scald water by two logs or more (Lillard et al., 1987). In the case of a lower scald temperature in the first tank of a three-tank scalder, there still would be two subsequent scald tanks to dilute any increased number of bacteria that might be left in wet feathers after the first tank.

The different scalding temperatures in the first tank had no effect on tenderness of cooked breast meat (Table 2). Mean Warner-Bratzler shear values for both treatments fell in the slightly-tough-to-slightly-tender range when human taste panel tenderness scores were compared to Warner-Bratzler shear measurements (Lyon and Lyon, 1990). Longer scalding times have been reported to increase the toughness of cooked chicken and turkey breast meat (Koonz et al., 1954; Shannon et al., 1957; Klose et al., 1959; Pool et al., 1959); but in this experiment tenderness was not different in meat from carcasses scalded at 57 C for either 2 min (CONTROL) or 1 min 20 s (LOWSCALD). Koonz et al. (1954) found that an additional 60 s in 60 C scald water toughened breast meat. Scalding for 25 s longer in 60 C water increased breast meat toughness in carcasses aged 24 h before deboning but had no effect on breast meat deboned 3 h postmortem (Klose et al., 1959). In another study using 60 C scald water, increasing scald time from 25 to 50 s caused significant toughening in breast meat deboned at 3.5 h (Pool et al., 1959). In the present experiment, scalding 40 s longer at 57 C had no effect on tenderness in breast meat deboned

TABLE 2. Warner-Bratzler shear force of cooked breast meat pieces and feather score of defeathered carcasses after two scalding treatments (means ± SD)

Scalding treatment[1]	n	Warner-Bratzler shear force (kg)[2]	Defeathering score[2,3]
CONTROL	24	9.3 ± 4.3	2.5 ± 1.1
LOWSCALD	24	8.6 ± 4.7	2.5 ± 1.0

[1]All carcasses were scalded to simulate a three-tank scalder with a total scald time of 2 min: 40 s in the scald water, 15 s out of the water, 40 s in the water, 15 s out of the water, 40 s in the scald water. CONTROL scald water temperature was 57 C. LOWSCALD water temperature was 24 C during the first 40-s scalding, then 57 C in the last two 40-s intervals.

[2]Treatment means were not significantly different.

[3]Defeathering score was determined by using an arbitrary scale from 1 = well picked to 4 = poorly picked. No difference was observed in skin condition.

[4]G-R Electrical Manufacturing Co., Manhattan, KS 66502.

at 4 h postmortem. Scalding in three 40-s sessions with 15-s intervals between tanks may reduce the temperature eventually reached by the breast muscle during scalding, thus having less of a toughening effect (Wise and Stadelman, 1959, 1961), compared to a continuous 2-min scald. Another possibility is that the birds and the processing equipment have changed so much that the older findings are no longer applicable under modern conditions.

The different scalding temperatures in the first tank also had no effect on removal of feathers from the carcasses (Table 2). Some feather tracts have been reported to respond differently to water temperature and length of exposure to scald water. Webster et al. (1996) speculated that body mass under feathered areas of the carcass might reduce the heating effect of scald water, with wing feather follicles heating faster than follicles on the main part of the carcass. Feather scoring in the present experiment was based on total number of feathers, without noting numbers of feathers in specific areas of the carcasses, but no obvious differences were seen in the location of any remaining feathers. No differences were observed in skin condition.

We have heard anecdotal claims that efficient heat transfer to some feather-covered areas of skin takes place only after feathers are completely wet. If that is correct, the early part of scalding may accomplish wetting of feathers more than heat transfer to feather follicles. Coverage of skin by feathers is variable, with birds having apteria, or areas of skin with no feather tracts, and pterylae, or areas of skin with feather tracts (Lucas and Stettenheim, 1972). Some feather tracts are more protected by overlying feathers. Before scalding, there are significant differences in the amount of force necessary to pull feathers from different feather tracts (Dickens and Shackelford, 1988; Buhr et al., 1997).

Compared to scalding with a constant water temperature of 57 C in a three-tank scalder, scalding at 24 C in the first tank followed by 57 C in the second and third tanks did not affect ease of feather removal, cooked breast meat tenderness, or carcass bacteria as measured by SPC, *E. coli*, and salmonellae incidence in rinses of defeathered carcasses. The water temperature (24 C) in the first scald tank in this experiment was much lower than temperatures in usual practice, but there may be energy savings from using a somewhat lower water temperature in the first scald tank. It appears feasible for plants to cautiously lower the water temperature in the early part of scalding to determine whether energy use can be reduced without adversely affecting the efficiency of feather removal or carcass microbiology under industrial conditions.

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