Subcutaneous Temperature Profile, Skin Appearance, and Picking Efficiency of Immersion and Spray Scalded Broiler Carcasses

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ABSTRACT To compare immersion and spray scalding temperature profiles, thermocouples were positioned beneath the skin of broiler carcasses in eight separate locations. The locations were as follows: 1 and 2) the upper left and right breast, 3 and 4) middle of the left and right thigh, 5 and 6) beneath the left and right wing, 7) the lower back above the pygostyle, and 8) the upper back between the wings. Standard immersion scalding at 52 or 56.5 C for 2 min or a prototype spray scalder at 60, 65, or 70 C for 1 min were used to monitor s.c. temperature during scalding. Immersion scalding resulted in an exponential profile with the lower temperature having less temperature deviation for the monitored locations. Among sampling locations, the spray scald temperatures were divergent among locations and the highest temperatures were recorded when thermocouples were within the spray patterns. As with the immersion scalded carcasses, lower temperatures for the spray scalding demonstrated less deviation among the monitored locations and a closer grouping of the final temperatures. The only spray scald temperature tested at which s.c. temperatures approached those of the immersion scalded carcasses was 70 C. Additional carcasses were scalded, picked, and examined for skin appearance and picking efficiency. All carcasses spray scalded for 60 s had a “cooked appearance” when evaluated. When spray scald times were reduced to 30 s, skin appearance improved, but with the exception of the 70 C trial, picking efficiency was poorer.

(Key words: scalding, temperature profile, defeathering, skin appearance, broiler)

INTRODUCTION

Cross contamination of broiler carcasses during the commercial processing operation of immersion scalding, as well as other processing operations, has become a major concern for the poultry industry. Standard scalding techniques in the U.S. consist of submerging carcasses in an agitated community bath at 50 to 60 C for 2 to 2.5 min. Because the scalding process is a community bath, one contaminated carcass could contaminate many other carcasses. Mulder et al. (1978) reported that when a carcass was artificially inoculated externally with a marker organism and placed into a standard immersion scalder, 230 subsequent carcasses were found to be contaminated with the marker organism. Lillard (1973) reported that when scald water contaminants enter the broiler’s respiratory system during immersion scalding, they can be spread to the circulatory system and to the internal organs, and possibly throughout the entire carcass. Her research showed that when a marker organism (Serratia marcescens) was introduced into the scald water, sampled internal organs were contaminated with the marker organism.

The fecal material from the growout houses and transport containers on the feathers and feet of broilers and fecal material excreted from the intestinal tract can contaminate the scald water, thereby contaminating subsequent carcasses that pass through the scalder. The turbulent action of the scald water is needed to ensure adequate heat transfer, but it also washes the fecal material from the carcass, and thus could contaminate other carcasses. Because improvements in processing equipment efficiency have enabled line speeds to be increased 50% or more, space limitations have often kept bleeding times from increasing proportionally. This situation creates the possibility that final defeation of the bird, (at or soon after death), can occur in the scalder rather than during bleeding.

Research testing various types of scalding have included the objective of decreasing the microbial load on the carcasses. Kaufman et al. (1972) reported that the microbiological quality of carcasses tested after chilling was about the same for standard tank immersion...
scalding and subatmospheric steam scalding. Patrick et al. (1972) found that steam scalded carcasses had significantly lower total bacterial counts than hot water immersion scalded carcasses when sampled after scalding and picking. Both methods of scalding used similar exposure time and temperatures.

Lillard et al. (1973) reported on the microbiological comparison of subatmospheric steam and standard immersion scalded broilers. Their research showed that, of the lungs from carcasses tested prior to scald, only 2 out of 26 were positive for Clostridium perfringens. Fifteen out of 26 carcasses had lungs that were positive after standard water scalding, but only 2 out of 37 were positive after subatmospheric steam scalding. These researchers agreed that standard immersion scalding of carcasses could contribute significantly to the contamination of broiler carcasses during processing.

Dickens and Lillard (1988) reported on a prototype spray scalding method for poultry processing. This research demonstrated the feasibility of a new scalding technique that would give comparable picking efficiency to immersion scalding. The objective of the present study was to compare physical parameters of temperature, picking efficiency, and appearance of carcasses treated with a prototype spray scalding machine to an immersion scalding machine operating at various temperatures.

MATERIALS AND METHODS

General

Mixed-sex broilers 48 d of age were obtained from a local processing plant, cooped, and transported to the research facility in a covered truck. All birds were weighed prior to stunning in a brine stunner preset to 50 V alternating current for 10 s (head to foot contact) and reweighed after their specific treatment. These weights were used to calculate possible differences in the water uptake of immersion vs spray scalded carcasses. Stunned broilers were then placed into bleeding cones, the carotid arteries and jugular veins on both sides of the neck severed, and the stunned birds allowed to bleed for 90 s.

Temperature Profile

After exsanguination, type “T” thermocouples were inserted in the eight locations beneath the skin and secured in place with nylon tie straps (Figure 1). To facilitate the insertion of the thermocouples, a sheet metal scribe was used to pierce the skin at the insertion point. Thermocouples were then inserted and pushed 2.5 cm cranially from the insertion point parallel to the skin surface. Thermocouple placement locations were as follows; 1) right and 2) left upper pectoral feather tract (upper breast), 3) right and 4) left mid-femoral feather tract (thighs), 5) right and 6) left lateral body feather tract (beneath the wings), 7) the cranial edge of the dorsal caudal feather tract (above the pygostyle), and 8) the interscapular feather tract (between the wings). All scald water temperatures were monitored with an electronic thermistor connected to a Stolab electronic thermometer. Carcasses were shackled and scalded by either immersion at 52 or 56.5 C for 2 min or by a steam-hot water spray at 60, 65, or 70 C for 60 s in a Johnson Food Equipment Co. prototype spray scalder. Two additional carcasses preceded and followed the carcasses connected to the thermocouples to ensure that recording conditions were identical to standard commercial processing conditions. Subcutaneous temperatures were recorded for each scald treatment using a Metrosonics Model d1-714 eight channel data logger. The Data logger was programmed to read each thermocouple once every second and record the average temperatures every 5 s. Data from each trial were then downloaded to a computer and prepared for analysis. There were three carcasses tested per replication and three replications completed for each of the five scald temperatures for a total of 45 monitored carcasses. The immersion scalder was operated a minimum of 30 min after reaching the correct temperature to ensure that the temperature controller was maintaining the water temperature to ± 0.5 C. The spray scalder was allowed to operate for 30 s to insure the starting temperature was ± 1 C before allowing the carcasses to enter. Carcasses were timed in the immersion scalder on a stopped line, whereas the line speed on the spray scalder was adjusted to allow 60 s inside the spray cabinet.

Skin Appearance

In separate trials, three replications of four carcasses at a time were scalded using the same parameters as previously described and passed through a single-stage commercial picker for 30 s. These picked carcasses were visually evaluated for skin appearance by the researchers. In any group in which two or more carcasses had a cooked
or denatured protein appearance, the group was eliminated from the subsequent testing for picking efficiency.

**Picking Efficiency**

Immersion scalded carcasses (56.5 C for 2 min) and spray scalded carcasses (70 C for 30 s) were evaluated for picking efficiency. The time was reduced to 30 s in the spray scaler because the skin of all carcasses exhibited a denatured protein or cooked appearance. Also, the 70 C spray was the only treatment in which the carcass temperature approached those of the immersion scalded carcasses. All carcasses were then passed through a Gordon-Johnson single pass picker with five banks of picker fingers, and the line speed adjusted for 30 s in the picker. Defeathered carcasses were scored as either 1, 2, or 3. A score of 1 indicated the absence of feathers; a score of 2 indicated a few feathers were present; a score of 3 indicated several feathers remained on the carcass and might be considered unacceptable to the consumer. The pilot plant facility at the research lab has only one picker, therefore a totally featherless pick is almost impossible. The three-point scoring system was used without regard to the tail feathers for the initial assessment. Carcasses were evaluated individually by three researchers and grouped for uniformity. Intermediate carcasses were then placed in the appropriate group by a consensus of the same three researchers. When a consensus was reached, the tail feathers were counted and recorded for further verification of the efficacy of the scald treatments.

**Statistical Analysis**

Temperature data were analyzed by the General Linear Models (GLM) procedure of SAS (SAS Institute, 1996) for replication differences. When none were found, simple means of the data were used for the profile graphs. Scores of defeathering were analyzed for main effects by chi-square (P < 0.05; Ott, 1988) using the values for the immersion scalded treatment as the expected value. The number of tail feathers remaining were analyzed with the GLM procedure of SAS. The error term was calculated using replication within treatments.

**RESULTS AND DISCUSSION**

**Temperature Profile**

All carcasses used for temperature monitoring were selected to weigh between 1,900 and 2,000 g, whereas the carcasses on either side of the monitored carcasses were not selected by weight. The left side of the carcasses entered the water first irrespective of the scald treatment. The 52 C immersion scalded carcasses demonstrated a close grouping of final temperatures (46 to 51 C) with an almost linear increase at all monitored locations (Figure 2). Locations with the highest recorded temperatures were the left breast and left thigh locations (51 and 50 C respectively), whereas the lowest temperatures were the right breast and right wing locations (47 and 46 C). The 56.5 C immersion scalded carcasses had a wider spread of temperatures, with some locations demonstrating a linear increase whereas other locations demonstrated an initial exponential increase (Figure 3). The higher temperature immersion scald had a wider spread of temperatures in the first 30 s (42 to 53 C); however, as time increased to the maximum of 2 min, the temperature spread narrowed (46 to 54 C). The thigh locations had the highest recorded temperatures for the 56.5 C immersion scald (51 and 56 C), with the right thigh having the highest recorded temperature, and the left side breast and right wing locations having lowest temperatures (46 and 48 C).

Data from the spray scalding test generally followed similar patterns in temperature differences, but the curves were more exponential after the initial lag phase of approximately 15 s. There were close groupings during the initial 20 s in the spray, after which the curves showed many highs and lows. These variations in the s.c.

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**FIGURE 2.** Temperature profile of broilers immersion scalded at 52 C; T1 = left breast, T2 = right breast, T3 = left thigh, T4 = right thigh, T5 = beneath left wing, T6 = beneath right wing, T7 = lower back, and T8 = upper back.

**FIGURE 3.** Temperature profile of broilers immersion scalded at 56.5 C; T1 = left breast, T2 = right breast, T3 = left thigh, T4 = right thigh, T5 = beneath left wing, T6 = beneath right wing, T7 = lower back, and T8 = upper back.
FIGURE 4. Temperature profile of broilers spray scalded at 60°C; T1 = left breast, T2 = right breast, T3 = left thigh, T4 = right thigh, T5 = beneath left wing, T6 = beneath right wing, T7 = lower back, and T8 = upper back.

FIGURE 5. Temperature profile of broilers spray scalded at 65°C; T1 = left breast, T2 = right breast, T3 = left thigh, T4 = right thigh, T5 = beneath left wing, T6 = beneath right wing, T7 = lower back, and T8 = upper back.

FIGURE 6. Temperature profile of broilers spray scalded at 70°C; T1 = left breast, T2 = right breast, T3 = left thigh, T4 = right thigh, T5 = beneath left wing, T6 = beneath right wing, T7 = lower back, and T8 = upper back.

temperatures were due to the inherent spray patterns of the manifold. High temperatures were recorded when there was direct contact by the spray pattern, and low temperatures were recorded when there was no direct contact of the spray pattern (Figures 4, 5, and 6). Temperature profiles of all spray scald trials generally narrowed and declined toward the end of the 60 s spray, due to the inherent properties of the spray pattern, with the highest temperatures recorded at or near 45 s exposure time. In general, the right breast location had the highest recorded temperature for all spray scald treatments. No definite pattern was observed for the location exhibiting the lowest temperature readings. It was expected that the left wing location would be among the lower recorded temperatures because the left side of the carcass was the leading side and was being pushed into the spray. Also, most of the spray nozzles were directed perpendicular to the carcass into the direction of travel and there were more nozzles directed from the back side than the front. Both of these factors would force the left wing toward the body area, thereby protecting the left thermocouple placement. There were no other general trends for temperatures with regard to location.

Highest overall temperatures were reached at or near 45 s into the spray scaler. Maximum carcass tempera-
tures reached after exposure to various spray temperatures were 51°C for the 60°C scald, 55°C for the 65°C scald, and 62°C for the 70°C scald, all recorded for the left breast location. Lowest high temperatures for the three spray scald treatments were 40°C at the right breast location for the 60°C spray, 44.5°C on the back location for the 65°C spray, and 46°C for the left thigh and back locations for the 70°C spray. The range in temperature for the three spray treatments were 12°C (39 to 51), 14°C (41 to 55), and 18°C (44 to 62) for the 60°C, 65°C, and 70°C spray treatments, respectively.

One interesting point of temperature deviation was the initial temperatures at 0 s. The initial temperatures were reflective of body temperature recordings just prior to entering the scald treatments. These temperatures ranged from a low of 34.5°C to a high of 42°C and were basically independent of thermocouple location with the exception of the pygostyle location, which had the highest initial temperature in four of the five treatments. This higher temperature was probably due to the heavier feathering and thicker skin found at this particular thermocouple location, and the proximity to the abdominal viscera. However, these factors did not have a continued effect during the subsequent scalding treatments.

Skin Appearance

Skin appearance of carcasses ranged from those with the cuticle layer of the epidermis intact to carcasses with skin that appeared to be cooked and that tore during defeathering. As would be expected, the carcasses immersion scalded at 52°C had complete cuticle layers of the intact epidermis, whereas carcasses immersion scalded at 56.5°C had a white appearance and the cuticle layer was totally removed during picking. Skin of all carcasses spray scalded for 1 min had a white, cooked (denatured protein) appearance, and was frequently torn during picking. Spray scald times were reduced to 30 s and reevaluation resulted in all carcasses having similar appearance to the skin of the carcasses immersion scalded at 56.5°C. However, due to the severe decrease in picking efficiency, evaluated by the number of feathers remaining on the
carcass after picking, the 60 and 65 C spray scalded carcasses were eliminated from the picking efficiency trials. The 70 C spray scald treatment was the only treatment in which the majority of the s.c. temperature locations approached the temperature of immersion scalded carcasses after 30 s (48 and 50 C for the 52 and 56.5 C scald temperatures, respectively). This result, along with decreased picking efficiency, was the primary rationale behind the decision to only evaluate picking efficiency at the 70 C spray treatment.

**Picking Efficiency**

All immersion scalded carcasses had consistently better picking efficiency scores; however, the differences were not significant (Table 1). Spray scalded carcasses had significantly more tail feathers retained (14.6) than the immersion scalded carcasses (5.4). These small but significant differences indicate that adjustment of the spray nozzles and nozzle patterns may minimize any difference in defeathering efficiency between the scalding methods. Initial body weight and carcass weight after bleeding, scalding, and picking did not differ between scalding methods. There was a significant ($P < 0.05$) difference in the weight after picking, with the immersion scalded carcasses losing 1.5% less weight than the spray scalded carcasses. Water uptake during immersion scalding seems to be the logical assumption to explain this difference.

Modifications of the spray scalding and picking system should result in a feasible alternative to immersion scalding if some additional incentives could be realized by poultry processors. Dickens and Lillard (1988) found no differences for spray and immersion scalded carcasses in total plate or Enterobacteriaceae counts; however, their work utilized a spray scalding operating at 60 C, which is 10 C lower than that of the present study. Additional research is needed to evaluate the present spray scalding with immersion scalding to determine whether carcass microbiological quality is influenced by higher scald temperatures. Better external and internal microbiological quality of processed carcasses would be a sufficient incentive to make spray scalding an economically feasible alternative to immersion scalding.

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**REFERENCES**


