

Effect of Prepackage and Postpackage Pasteurization on Postprocess Elimination of *Listeria monocytogenes* on Deli Turkey Products

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ABSTRACT

Surface pasteurization for inactivation of *Listeria monocytogenes* was evaluated for radiant heat prepackage pasteurization, submersed water postpackage pasteurization, and combinations of the two techniques on various types of ready-to-eat deli turkey products obtained from at least four different manufacturers. Products were inoculated either by in-package liquid inoculum or surface sponge-contact with approximately 10^9 CFU of *L. monocytogenes*. Additional testing of radiant heat pasteurization was performed with low-level inoculation of product undersides with approximately 100 CFU of *L. monocytogenes* followed by enrichment recovery after pasteurization. Prepackage pasteurization provided 2.0 to 2.8 log reductions when processed for 60 s and 2.8 to 3.8 log reductions when processed for 75 s. An improved radiant oven provided 3.53 (60 s) and 4.76 (75 s) log reductions of *L. monocytogenes*. No positive samples were detected after enrichment when 40 samples of deli turkey (4 to 4.5 kg) undersides were inoculated at low levels and processed for 75 s. Submersed water postpackage pasteurization provided 1.95 to 3.0 log reductions when processed for 2, 3, 4, or 5 min, and combinations of the two processes gave 3.0 to 4.0 log inactivation of *L. monocytogenes* using either 60 + 60 s or 60 + 90 s for the prepackage and postpackage pasteurization processes, respectively. These processes, either individually or in combination, can provide postprocess elimination of bacteria for the manufacture of safe ready-to-eat deli meats.

Raw poultry carcasses and meat portions are well known for having a high incidence of *Listeria monocytogenes* contamination (3, 9). This constant influx of *Listeria* from high-incidence raw materials can result in the establishment of *L. monocytogenes* in the downstream processing environment of poultry processors and possibly lead to contaminated fully cooked products (2, 10, 11, 14). Therefore, processing facilities that further process raw poultry into ready-to-eat (RTE) deli products must be vigilant to eliminate *L. monocytogenes* from finished product areas (15).

In recent years, a large listeriosis outbreak was epidemiologically linked to deli turkey products and was implicated in 29 cases of illness and four deaths, resulting in the recall of 17 million pounds (7.7×10^6 kg) of deli turkey products (4). More recently, a large foodborne outbreak of listeriosis in the northeast United States, thought to involve deli turkey, resulted in 13 deaths and 43 illnesses (5). Isolates of *L. monocytogenes* from the deceased victims had the same DNA fingerprint as that found in a nonfood contact surface environment of one processor, resulting in a large recall of 28 million pounds (12.7×10^6 kg) of deli turkey products. In response to the continuing detection and isolation of *L. monocytogenes* in RTE products and processing facilities, the U.S. Department of Agriculture Food Safety and Inspection Service (USDA-FSIS) has proposed

more stringent regulations and testing standards for facilities that make such products (1).

Since the implementation of hazard analysis and critical control point (HACCP) food safety programs, *Listeria* contamination of RTE meat and poultry products has been one of the major concerns of the USDA-FSIS during HACCP program reevaluation. The USDA-FSIS has made several moves to provide incentives for processors to take additional steps to reduce risks associated with RTE meat and poultry products. One such move was a required *Listeria* reassessment to determine whether *L. monocytogenes* was a pathogen that was “reasonably likely to occur” in the postprocessing environment. If so, then processors should consider implementing a critical control point to assure that it is eliminated, prevented, or reduced to an acceptable level. Another move by the USDA-FSIS was Directive 10240.3 (16), which identified various product risk categories (high, medium, low) for various RTE meat and poultry products and indicated that processors who implemented postprocess lethality steps could put their high- or medium-risk product into the low-risk category, which carries with it the incentive of reduced government testing. The most recent regulatory move was the final rule (1), which identified three alternatives that determine the degree of government testing: alternative III whereby sanitation alone is used to control *Listeria* (most testing), alternative II whereby a processor uses either a postprocess bactericidal step or antimicrobial ingredients to control *Listeria* (less

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testing), or alternative I whereby a processor uses both a postprocess bactericidal step and antimicrobial ingredients to control *Listeria* (the least testing).

Postcook surface pasteurization is not a newly proposed process; however, most of the early literature deals with beef products (6, 8). In prior work, we reported that *L. monocytogenes* inoculated onto the surface of deli-size ham, turkey, and roast beef was reduced by postpackage pasteurization via submersion in hot water for various time periods. This process was initiated in response to the 1998 listeriosis outbreak and subsequent product recall (12) and was quickly put into commercial practice as a means of producing safe RTE products. Murphy et al. (13) obtained similar results with in-package submersion heating of 4-kg deli turkey breasts inoculated with *L. monocytogenes*. Reduction of *Listeria* was followed for up to 50 min of heating time, and a 2.5 log reduction was found after about 5 min at 96°C. The extended heating time required by postpackage water submersion generates moderate amounts of purge, which is undesirable. We therefore examined radiant heat (prepackage) pasteurization of pastrami, ham, corned beef, and roast beef as a means of reducing surface listerial contamination prior to packaging. A radiant heat oven, either alone or in combination with postpackage pasteurization, was used in that study (7). Here, we describe the use of prepackage, postpackage, and combination pre- and postpackage pasteurization for reduction of *L. monocytogenes* on deli turkey products, which have been the subject of listeriosis outbreaks and product recalls in recent years.

MATERIALS AND METHODS

Bacterial cultures and growth conditions. A mixture of four strains of *L. monocytogenes* (Scott A-2, serotype 4b; V7-2, serotype 1/2a; 39-2 retail hotdog isolate; 383-2 ground beef isolate) was used for the inoculation trials. These strains were resistant to streptomycin (100 µg/ml; Sigma Chemical Co., St. Louis, Mo.) and rifamycin S/V (10 µg/ml; Sigma) and were plated on tryptic soy agar (TSA; Difco, Becton Dickinson, Sparks, Md.) containing these antibiotics for enumeration of inoculated cultures on nonsterile product. This approach allows the recovery of viable and heat-injured cells without the need for harsh selective media that may prevent the growth of heat-injured cells (e.g., modified Oxford agar) and allows selective enumeration in spite of indigenous contaminating bacteria. These modifications have not affected the heat sensitivity of these strains; *D*- and *z*-values are similar to those reported in the literature for *L. monocytogenes* (12). Bacterial strains were cultured by transferring 100 µl of thawed frozen culture into 10 ml of brain heart infusion broth and incubated overnight at 30°C. Overnight cultures were then mixed in equal proportions, and 100 µl of the mixture was surface plated onto TSA that was held overnight at 30°C for use the next day as the mixed culture source for contact inoculations.

Product inoculation. Samples of RTE deli turkey products were received from various manufacturers for use in surface pasteurization trials (oven-roasted turkey, seasoned turkey, oil browned turkey, skin-on turkey, turkey pastrami) and generally weighed 4 to 11 lb (1.8 to 5.0 kg). All products were sent directly from processors after manufacture, stored at 2°C (35.6°F), and used within 1 to 2 weeks of receipt. Immediately before use, products were taken from refrigerated storage, removed from their packaging, and inoculated with *L. monocytogenes* by a contact

inoculation method. Control samples for each product type were also inoculated for each replication trial but were not heated; these samples were used to determine the basal recovery level for the inoculated microorganisms. For contact inoculation, a sponge-foam padding material (ca. 5 to 6 cm thick) was cut to the shape of a petri plate, autoclaved in foil-covered beakers, and used with a pressing and twist motion to pick up the mixed-strain inoculum lawn from inoculated petri plates after overnight incubation on agar (Fig. 1). The inoculum was then contact inoculated onto the surface of the product top, sides, and bottom with the same pressing and twisting motion. The inoculated product was then placed on the conveyor leading into the radiant heat oven. As determined from nonheated control samples, the contact inoculation method provided initial concentrations of 1 to 3×10^9 CFU per product sample.

Prepackage pasteurization. A radiant heat oven (480 V, 30 Amp; Infrared Grill, Unitherm Foodsystems, Bristow, Okla.) was installed in our pathogen-processing pilot plant and used for prepackage pasteurization (7). Modifications to the oven included the placement of bottom heating coils closer to the stainless steel mesh conveyor belt and the addition of more coils below the belt to improve the heating of the lower side of product surfaces. All product pieces were heated at full power (no. 5 dial setting; approximately 399°C [750°F] above the product surface) for 50, 60, or 75 s (based on product transit from the first to last heating coil). Treatment times were adjusted by altering the speed of the conveyor belt. After passage through the oven, product samples were transferred to a sterile bag, chilled in an ice-water slurry, and rinsed with a chilled sterile diluent (50 ml of 0.1% buffered peptone water [BPW]) to recover cells for microbial analysis (usually within 15 to 20 min). Inoculated but unheated control samples were treated similarly.

Postpackage and combination pre- and postpackage surface pasteurization. Deli RTE turkey products were also surface pasteurized by submersed water postpackage pasteurization as described previously using a 50-gal (189 liter) steam-injected temperature-controlled water bath (12). For samples processed by postpackage pasteurization alone, we used 25 ml of inoculum. After pasteurization, a 50-ml 0.1% BPW rinse was used to recover the remaining viable cells. For samples processed in conjunction with trials combining prepackage and postpackage pasteurization, all samples were inoculation by contact inoculation followed by a 50-ml rinse with 0.1% BPW. The combination pasteurization process included a short prepackage pasteurization treatment (45 or 60 s) followed quickly by vacuum packaging and postpackage pasteurization at 93.3°C (200°F) for 45, 60, or 90 s. Product surface temperatures were obtained using an infrared digital thermometer (Raynger Model ST80, Raytek, Santa Cruz, Calif.) that could provide the average temperature of the locations of eight infrared dots projected onto a product in a circular pattern.

Bottom inoculation of RTE deli turkey. For one series of product trials, we inoculated only the bottom of oven-roasted deli turkey (~4.0 to 4.5 kg) with ~100 CFU of *L. monocytogenes* followed by enrichment recovery to see whether a low level of inoculation or contamination could be completely eliminated by radiant heat processing. A four-strain mixture of our *L. monocytogenes* cultures was diluted using 0.1% BPW to provide roughly 100 CFU per 0.5 ml (based on expected levels). A sheet of Saran wrap was placed on foil-covered trays, and 0.5 ml of the diluted culture was applied to the middle of the sheet. An oven-roasted deli turkey was then placed onto the 0.5 ml and rubbed forward, backward, sideways, and in circles to pick up the inoculum. After

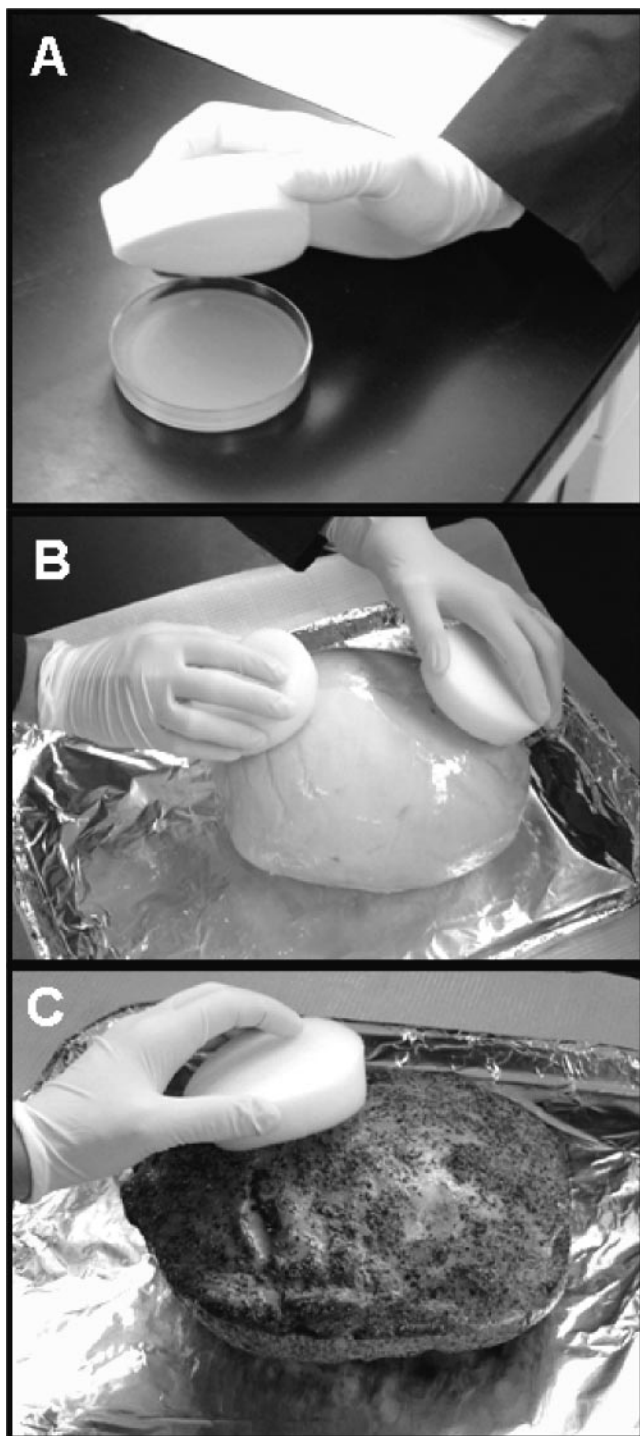


FIGURE 1. Surface contact inoculation using sterile round sponge padding to take up the lawn of *L. monocytogenes* from petri plates (A). Contact inoculation is applied to oven-roasted (B) and pepper-seasoned (C) turkey products by a twisting motion upon contact. One inoculated plate was used per piece of turkey product.

inoculation, the product was processed through the radiant heat oven for 75 s within 5 to 10 min after inoculation. The Saran wrap was then discarded and replaced with a new piece, and other product samples were inoculated in the same manner. Any remaining noninoculated cells were recovered from the Saran wrap by applying 5 ml of 0.1% BPW to resuspend any remaining cells. The entire rinse solution was added to 50 ml of TSA containing

the appropriate antibiotics, mixed, poured into three petri plates, and incubated at 30°C. The total count from the three plates for each sheet of Saran wrap was subtracted from the count obtained for the 0.5-ml inoculum so that the exact amount inoculated could be determined. Subsequently, bottom inoculation was simplified by pipetting 0.5 ml over the flat bottom of an overturned product and using a gloved finger to spread the inoculum over the bottom surface, thereby eliminating the need to quantitate residual uninoculated *Listeria*. Because of the extremely low (or nonexistent) number of bacterial cells that may remain on the product bottom after processing, we used an enrichment technique on the entire 4.0- to 4.5-kg (10 to 12 lb) product to determine whether there were any viable cells remaining. After processing, the entire oven-roasted turkey product was placed into a large bag with 250 ml of tryptic soy–streptomycin–rifamycin enrichment broth. The enrichments were incubated for 24 h at 30°C and shaken to mix, and 1-ml aliquots were inoculated into Fraser broth containing the antibiotics to which our cultures were resistant. The lack of a black precipitate in the Fraser broth indicated that all the low-level inoculum was eliminated during processing. Darkening of the Fraser broth was consistent with the presence of our inoculated cultures in control assays, and samples of broth were further streaked onto modified Oxford agar containing streptomycin and rifamycin for further confirmation.

Yield loss determinations. Product yield loss was determined by weighing the product with an 8-kg capacity scale (Navigator 8100, Ohaus, Pin Brook, N.J.) before and after radiant heat treatment alone or the combination process, after prepackage pasteurization, and again after postpackage pasteurization. Yield loss (%) was determined as the weight difference relative to the original weight of the product.

Experimental design and statistical analysis. All trials were carried out in triplicate. Inoculated control samples and experimental samples were processed in pairs for each condition within a replicate, resulting in six product samples tested for any given condition. Different replications were carried out on separate days with different lots of the same product and with pairs of samples from the same lot for each test condition. Standard deviations around the means were obtained for the multiple test samples within the various replications. Treatment times were limited to those of practical application by the various participating processors. Statistical analysis was performed for multiple comparison of the means and standard deviations obtained for different products or treatments. An analysis of variance was performed using the Holm-Sidak test for pairwise multiple comparisons to determine significant differences ($P < 0.05$) using the software program SigmaStat 3.0 (SPSS, Inc., Chicago, Ill.).

RESULTS AND DISCUSSION

Radiant heating was previously shown to be an effective means for surface pasteurization of RTE deli ham and roast beef products (7). For either pre- or postpackage pasteurization, we have generally worked with residence times that are of practical use to the industry: long enough to provide significant microbial reductions but short enough to not impede production throughput. Using radiant heat prepackage surface pasteurization with high-level contact inoculation of turkey deli products, we were able to achieve a 2.0 to 2.8 log reduction of *L. monocytogenes* with a 60-s residence time or a 2.8 to 3.8 log reduction with a 75-s residence time (Fig. 2). Oven-roasted turkey processed for

Radiant Heat Surface Pasteurization

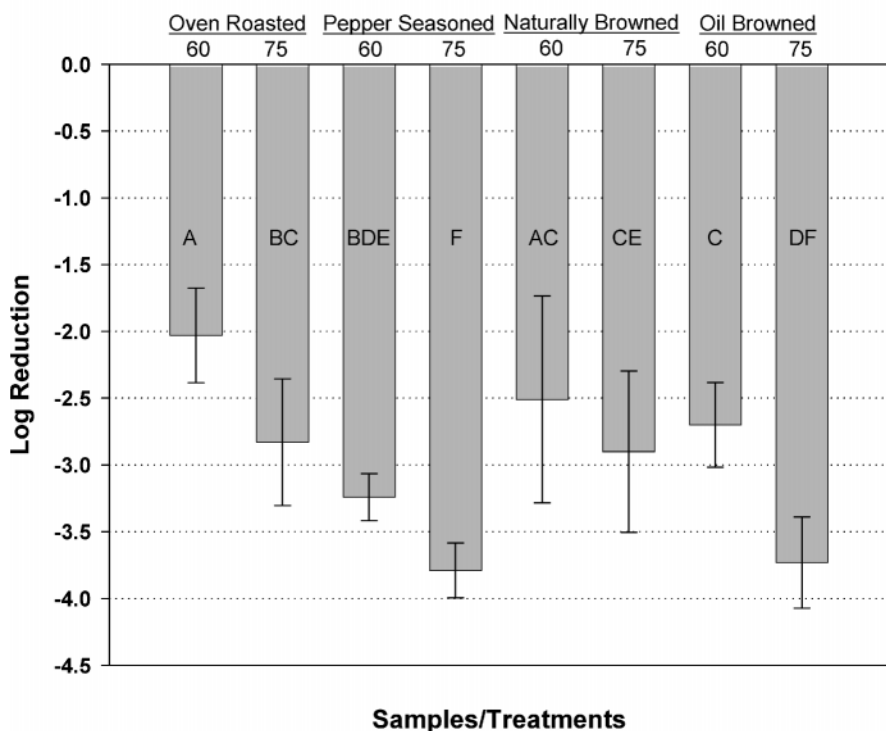


FIGURE 2. Prepackage surface pasteurization using a radiant heat oven on four types of deli turkey (oven roasted, pepper seasoned, naturally browned or skin on, and oil browned) from manufacturer A. Oven dwell time was either 60 or 75 s, as indicated. Error bars represent \pm SD of the means of three replicates (n = 6). Bars with the same letter are not significantly different ($P > 0.05$).

60 s (2.0 log reduction) and pepper-seasoned turkey processed for 75 s (3.8 log reduction) were significantly different ($P < 0.05$) from most other products tested, with the lowest and highest log reductions, respectively (Fig. 2). Oil-browned deli turkey had among the highest reduction in bacteria because the product surface is sealed during the frying process and the darkened surface color and residual surface oil absorbs radiant heat during passage through the heated coil tunnel. However, seasoned deli turkey was not expected to have as high a level of reduction because the pebbled seasoning on the product surface could shield bacteria from radiant heat. During heating, natural antimicrobials may be released from various seasonings that have been topically applied to the product (Fig. 2). Naturally browned turkey (i.e., skin-on turkey) produced the most variable results among the repetitively sampled product pieces, as indicated by the larger standard deviations in the

data (Fig. 2). Some of the inoculated bacteria could have been protected at the edges of the skin, which could have shielded the bacteria from the full heat regimen. Regardless of differences among product types, the lowest residence time used (60 s) provided at least a 2 log reduction of *L. monocytogenes*, providing a significant reduction in potential surface contamination just prior to packaging. However, to maintain the benefit of prepackage pasteurization, the product should be packaged as soon as possible (within 15 s) to prevent recontamination as surface temperatures quickly drop. Even when bagged this soon after processing, the product surface will have fallen to about 60 to 66°C (140 to 150°F), and product can be packaged in retail bags. Although recontamination may be a concern, the potential exposure time has been minimized from 12 to 16 h of chilling overnight on racks before packaging (without such processes) to within 15 s after removal from a radiant heat oven.

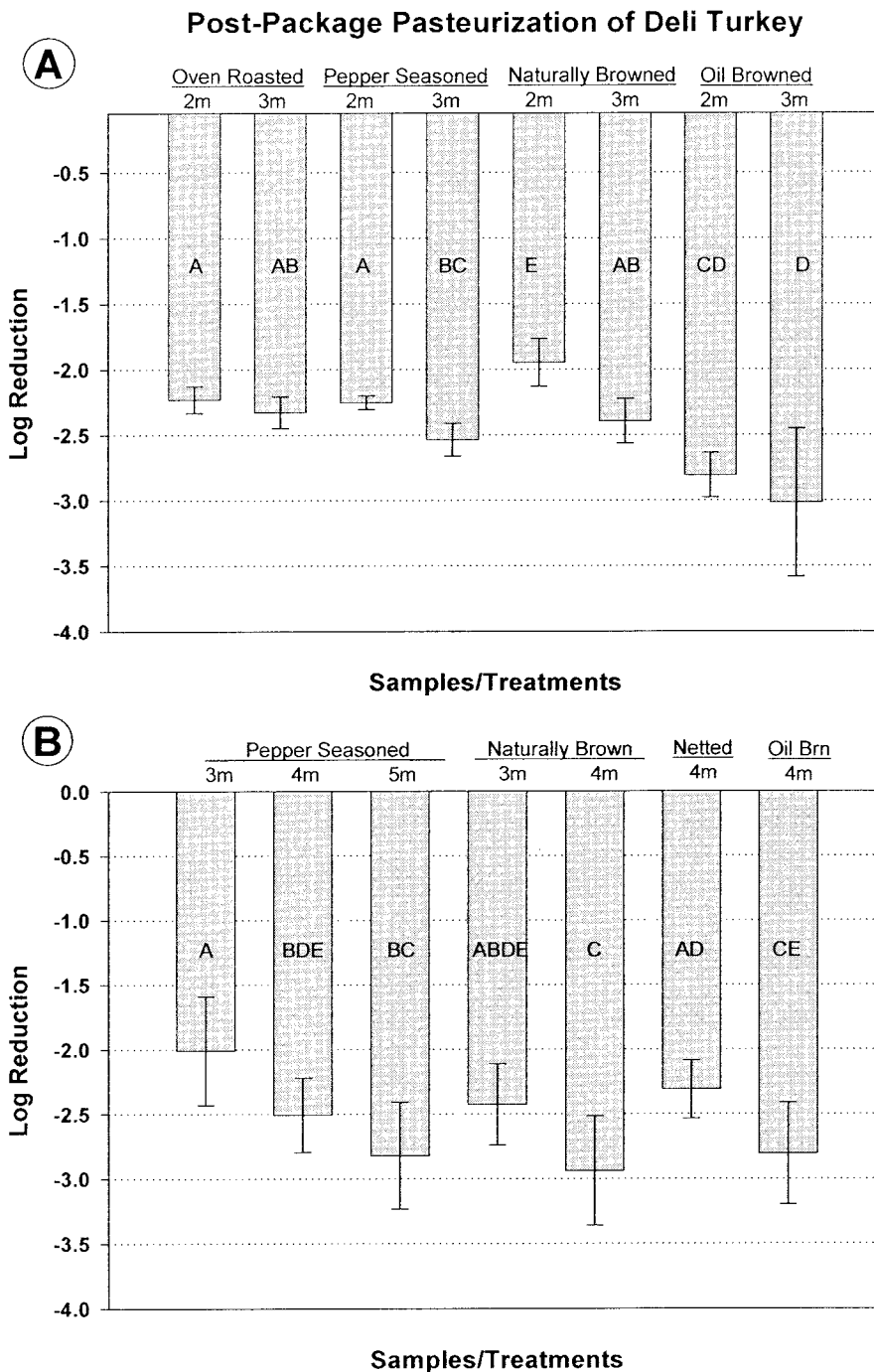
TABLE 1. Radiant heat prepackage pasteurization using either bottom or contact inoculation methods on oven-roasted turkey^a

	Bottom inoculation	Contact inoculation
Inoculation site	Bottom surface	Top, bottom, sides
Inoculation method	Product rub	Contact inoculation
Inoculation level (CFU)	10 ²	10 ⁹
<i>Listeria</i> recovery/detection method	Enrichment (yes/no)	Plate count
Number of samples tested	0 positive/40 tested	6 samples (60 s) 8 samples (75 s)
Log reduction of <i>Listeria</i>	>2.0 (75 s)	4.76 \pm 0.65 (75 s) 3.53 \pm 0.44 (60 s)
Negative controls	0 positive/30 tested	N/A ^b
Positive controls	4 positive/4 tested	N/A

^a The radiant heat oven was modified to improve heating of the bottom surface of the product.

^b N/A, not applicable.

FIGURE 3. Postpackage surface pasteurization of four types of deli turkey (oven roasted, pepper seasoned, naturally browned or skin on, and oil browned) using submersion heating in steam-injected water at 93.3°C (200°F). (A) Postpackage pasteurization for 2 and 3 min (product from manufacturer B). (B) Postpackage pasteurization for 3, 4, or 5 min (product from manufacturer C). Error bars represent ±SD of the means of three replicates (n = 6). Bars with the same letter are not significantly different (P > 0.05).



One consideration that we were able to address with the radiant heat oven was improved heating on the underside of the product. Although the underside is not the only contact surface or the only avenue for contamination, it is a major contact site because all exposed product will rest on one or more surfaces prior to packaging. Therefore, increased heating on the underside of the product may provide an improved processing scenario for insuring the safety of RTE deli products. This possibility was initially addressed by rotating the curved bottom heating elements close to the underside of the conveyor belt (7). This design was further improved by increasing the number of bottom heating elements and most recently by increasing the wattage output of the heating coils by a manufacturing modi-

fication. We also tested process lethality by using a low-level inoculation of product undersurface followed by enrichment recovery for *L. monocytogenes* (Table 1). With only approximately 100 CFU of *L. monocytogenes* inoculated on the bottom of surface, we did not recover any *Listeria* for the 40 pieces tested using a 75-s processing time. Using our normal contact inoculation method, we obtained a 4.76 log reduction under these same conditions when product was inoculated on all surfaces (Table 1).

We also examined reduction of *L. monocytogenes* on RTE deli turkey products by submersion heating, i.e., post-package pasteurization (12). The obvious benefit of post-package pasteurization is that there is no further handling of product after processing because it is already in the pack-

Prepackage, Postpackage, and Combination Pre-/Postpackage Pasteurization of RTE Deli Turkey

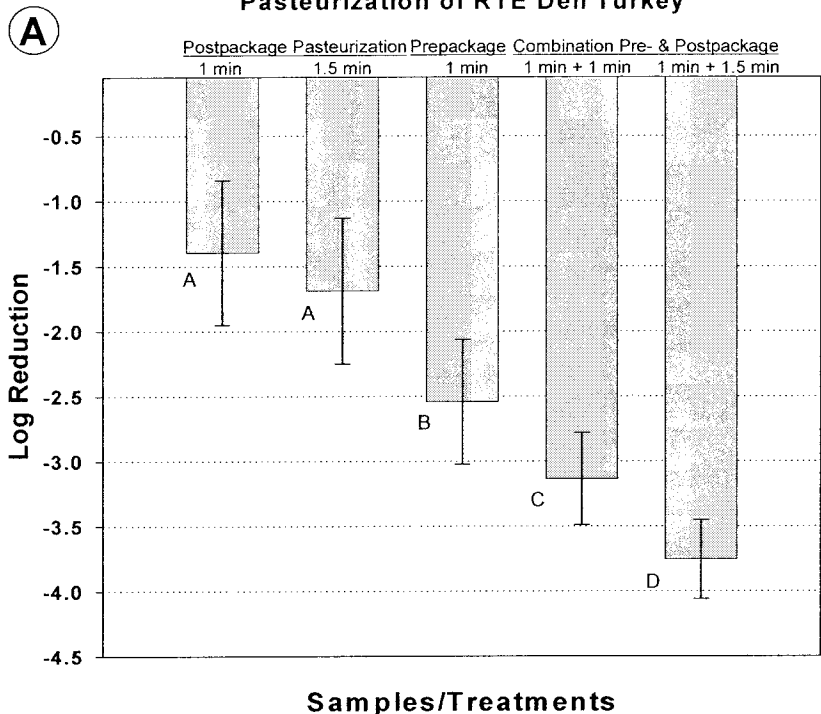
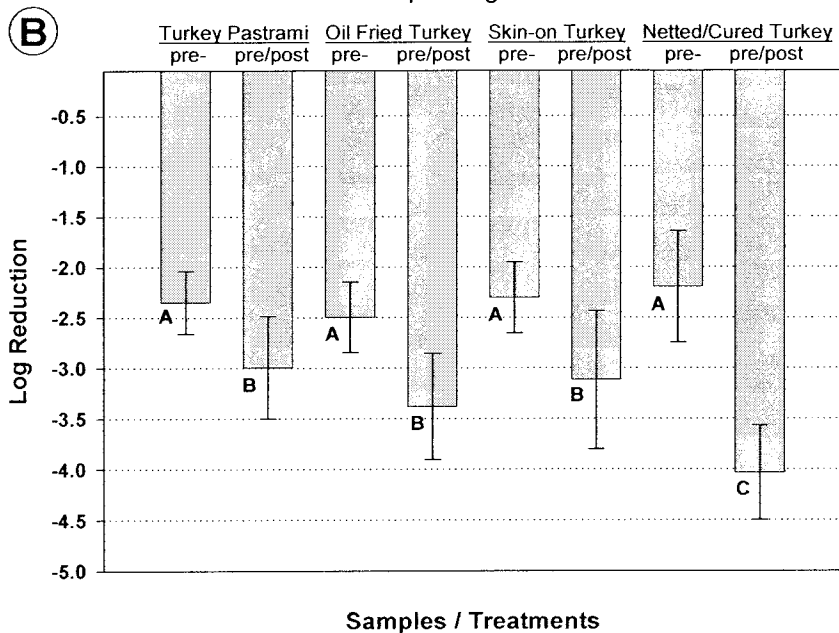


FIGURE 4. Combination pre- and postpackage pasteurization of deli turkey (manufacturer D). (A) Contact-inoculated oven-roasted deli turkey was prepackage pasteurized for 1 min alone, or in combination with postpackage pasteurization for 1.0 or 1.5 min at 93.3°C (200°F). (B) Prepackage pasteurization (60 s) and combination pre- and postpackage pasteurization (60 s + 60 s) of various deli turkey products. Error bars represent ±SD of the means of three replicates (n = 6). Bars with the same letter are not significantly different (P > 0.05); bars with different letters are significantly different (P < 0.05).

Combination Pre- and Postpackage Pasteurization of Deli Turkey



age. Postpackage pasteurization of various turkey products from manufacturer A for 2 or 3 min at 93.3°C (200°F) provided 1.95 to 3.0 log reduction of surface-inoculated *L. monocytogenes* (Fig. 3A). Postpackage pasteurization resulted in a significantly greater reduction in bacteria for oil-browned turkey from manufacturer B than for other products processed for the same residence time (3 min). However, oil-browned turkey from manufacturer C did not show significantly different reduction levels ($P > 0.05$) when processed for the same period (4 min) as other products from the same manufacturer (Fig. 3), suggesting that bactericidal effects may be affected by different manufacturing

conditions for apparently similar products. With deli turkey provided by manufacturer B, we also obtained 2.0 to 2.95 log reduction of inoculated *Listeria*, although residence times were 3, 4, or 5 min (Fig. 3B). As expected, increased residence time also led to higher reductions (within a product type). Differences in manufacturing among similar products from different processors (i.e., level and/or composition of injection) could account for dissimilar reductions obtained. All products tested had approximately 2 log reduction in bacteria or greater. Although postpackage pasteurization has the benefit of an in-bag process, the longer time required to obtain reductions similar to those obtained

TABLE 2. *Evaporative or purge-related yield loss (%) after radiant heat and/or postpackage pasteurization of various RTE deli turkey products^a*

Turkey product	Weight (kg)	Prepackage pasteurization (60 s)	Pre- and postpackage pasteurization (60 s + 60 s)
Manufacturer A			
Oven roasted	4.10	0.71	ND ^b
Oil browned	4.00	0.56	ND
Smoked honey cured	4.55	0.66	ND
Seasoned	2.40	1.27	ND
Cracked pepper smoked	4.20	0.66	ND
Honey cured	3.95	0.76	ND
Manufacturer B			
Pastrami	1.3	0.99	1.29
Netted cured	3.5	0.50	0.60
Oil browned	4.3	0.40	0.66
Skin on	4.36	0.69	1.07

^a Loss after pre- and postpackage pasteurization is the combined loss for both processes. Each figure is the mean of two replicate trials.

^b ND, not done.

with prepackage pasteurization may result in the generation of purge, which can reduce heat transfer at the product surface and can be aesthetically displeasing to customers.

To minimize the negative aspects of the individual processes for pre- or postpackage pasteurization, we examined a combination pre- and postpackage pasteurization process that was previously tested with ham and roast beef (7). The combination process works equally well with turkey products (Fig. 4). Because the prepackage pasteurization process does not need to penetrate the packaging film, radiant surface heating of exposed product provides greater microbial reduction than that obtained with postpackage pasteurization in the same amount of processing time (Fig. 4A). With the combination method, the product is vacuum packaged and immediately directed into the second phase for continued processing by postpackage pasteurization in hot water. In this combination approach, the water pasteurization step initiates pasteurization while the product surface is still warm (>26.7°C [80°F]) from the radiant heating instead of starting with a chilled product at 0 to 3.3°C (32 to 38°F). Furthermore, the minimal time spent in the submerged water phase of the combination process generates no purge, unlike the longer time intervals when postpackage pasteurization is used as a stand-alone process. Using a combination 60-s radiant heat process followed by either a 1.0- or 1.5-min postpackage pasteurization step, we were able to achieve a 3.15 to 3.75 log reduction in surface *Listeria* on oven-roasted turkey for a combined 2.0- or 2.5-min process, respectively (Fig. 4A). Similarly, using a combination 60-s prepackage process followed by 60 s of postpackage pasteurization with each of four different types of deli turkey products, we obtained a 3.0 to 4.0 log reduction (Fig. 4B). In each case, the combination provided a significantly greater bactericidal effect ($P < 0.05$) than did either of the individual processes, did not require further handling afterward, and did not generate any purge.

The product yield loss was less than 1% for most large products greater than 3.5 kg (Table 2), but the loss per-

centage may be greater for smaller products (1 to 3 kg). These losses may be influenced by levels of injection and ingredients that may help retard loss of water. Loss due to purge generation is minimized with the combination method because of the shorter postpackage pasteurization step in the combination process compared with the stand-alone postpackage pasteurization processes.

The pre- and postpackage pasteurization processes, either individually or in combination, produce substantial bactericidal effects on surface contamination and therefore should be considered postprocess bactericidal steps with regard to recent USDA-FSIS regulations, meeting the criteria for alternatives I or II (1). At first glance, postpackage pasteurization may be considered a better process because there is no further handling after pasteurization. However, because postpackage pasteurization occurs after vacuum packaging, any contamination that may have originally been on the periphery of the product surface may be pulled deeper into surface pores, cracks, or crevices. More rigorous treatment would then be needed to pursue bacteria in these areas. Prepackage pasteurization could more easily attack those bacteria that are initially on the periphery of the surface layer because it is applied before the product is vacuum packaged. In this context, prepackage pasteurization may be an important step in reducing *Listeria* that could be brought into contact with vacuum packagers (e.g., Cryovac 8600), which at best are difficult to clean. Prepackage pasteurization can produce significant reduction in contamination at the product surface before vacuum packaging and if followed by postpackage pasteurization provides additional reduction in any contamination acquired during packaging.

In addition to these antimicrobial benefits, radiant heating can also be used to simultaneously colorize or brown products to provide a more appealing roasted appearance while providing surface pasteurization, depending on the residence time or the prior addition of caramelizing colorants to the surface. Another benefit of using radiant heating

alone is that product can be packaged in ordinary retail bags, and savings realized from not using the expensive postpackage pasteurization bags could pay for the equipment in a short time. Our future efforts in this area will include heating and chilling issues associated with these processes.

Radiant heat surface prepackage pasteurization, alone or in combination with postpackage pasteurization, can provide significant reduction in *Listeria* surface contamination, which has been problematic for the RTE meat and poultry industry and most recently in deli poultry products. Although radiant heating is a prepackage pasteurization process and requires packaging immediately afterward, it may be better able to attack bacteria on the periphery of the product surface than would processes initiated after vacuum packaging. When prepackage and postpackage pasteurization processes are combined, they can eliminate negative aspects that may be associated with each individual process. The surface pasteurization processes described here provide postprocess bactericidal activity as acknowledged by the USDA-FSIS in recent directives and the final rule (1). Although these processes are lethal to surface contamination, they should be considered an adjunct to proper sanitation practices in the processing establishment and not a replacement for these practices.

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