Efficacy of selected chemicals on survival of *Salmonella* on turkey meat

A.H. Dinçer Baysal¹, A. Ünlütürk²

**SUMMARY**

The influence of dipping *Salmonella* inoculated turkey breast meat in lactic acid (LA), fumaric acid (FA), trisodium phosphate (TSP) and sodium tripolyphosphate (STPP) solutions on the elimination of *S.typhimurium* was assessed. Dipping fillets in 1% LA, 1.5% LA, 0.5% FA, 10% TSP and 10% STPP reduced the number of *S.typhimurium* by about 1.9, 2.7, 2.6, 3.5 and 3.2 log units, respectively. While there was only one *Salmonella* positive sample out of three samples 2 hours after dipping the fillets with an initial inoculum of 3.1 log CFU *Salmonella* per fillet in 1.5% LA solution, no *Salmonella* positive sample was observed out of three samples dipped in 10% TSP solution. There were no *Salmonella* positive samples with an initial inoculum of 3.1 log CFU *Salmonella* per fillet after 2 and 24 hours of dipping in 10% TSP solution. There were no *Salmonella* positive fillets out of three samples dipped in 1.5% LA and 10% TSP solution with an initial inoculum of 2.6 log CFU *Salmonella* per fillet after 2 and 24 hours period.

**Keywords**

fumaric acid, sodium tripolyphosphate, turkey breast meat, *Salmonella*, elimination.

**1 – INTRODUCTION**

Contamination of poultry products with pathogenic microorganisms is common. Among these microorganisms, *Salmonella* spp. and *Campylobacter* spp. are responsible for the largest proportion of poultry food-transmitted incidents of human infection (BEAN and GRIFFIN, 1990; BEAN et al., 1990; TAUXE 1991; TIEJEN and FUNG, 1995). The U.S. Department of Agriculture (USDA) estimates that close to 40% of all raw poultry is contaminated with *Salmonella* (RODRIGUEZ de LEDESMA et al., 1996). In other countries, researchers determined the prevalence of *Salmonella* in poultry products ranged from 13.7 to 60%: 13.7% in Switzerland, 26.6% in Tokyo, 43% in Ohio, USA, 55% in Portugal.
66% in Thailand (JERNKULCHAN et al., 1994; UYTEMDALE et al., 1998). Turkey meat is frequently identified as a vehicle in outbreaks of salmonellosis. Turkey carcasses and their parts are frequently contaminated with salmonella that reach the carcasses from the intestinal tract or from faecal material on feet and feathers. Cross-contamination is a particular problem; critical steps include defeathering, evisceration and chilling (ICMSF, 1998). Several recommendations have been published to control salmonellae throughout the chain from hatcheries to the preparation at home (ICMSF, 1998, MULDER and SCHLUNDT, 1999; HAFZ, 2000). Consumers demand safe food products and are unwilling to accept health risks that could be reduced by additional precautions being taken. For the future, dependable and safe production methods require developments in product and process safety. Thus, meat products must be safe, have a low spoilage rate, and have the right composition, packaging, colour, taste and appearance. The implementation of a HACCP system will force meat producers to study their production process and find, monitor and control the critical points. Together with improvements in meat processing equipment, this should help to control product safety. Another means of controlling or even improving the safety of food products is to decontaminate the carcasses or products during or at the end of the production line. Control by end-product decontamination is most attractive since it is applied just before the retailing of the carcasses or products and the loads of other pathogenic and spoilage bacteria also reduced. End product treatments that have been proposed for reducing or eliminating salmonellae from poultry carcasses in the processing plant include a variety of chemicals.

Organic acids, such as such as lactic acid (LA) have been used to sanitize carcasses because they exhibit good bactericidal activity and are generally regarded as safe (GRAS) additives (QUARTEY-PAPAFIO et al., 1980; IZAT et al., 1989; DICKSON and ANDERSON, 1992). In a series of trials, pure cultures of Salmonella typhimurium in a model broth and inoculated onto broiler carcasses were subjected to 1% LA for 10 min and the researchers reported complete inhibition of Salmonella on the carcasses (MULDER and SCHLUNDT, 1999). IZAT et al. (1989) showed that pre chill carcasses dipped for 2 min in 2% LA at 37°C were free of salmonellae. Fumaric acid (FA) is used for its good antioxidant properties in butter, cheese, powdered milk, frankfurters, nuts and potato chips, as an acidulant in beverages and also as an antimicrobial additive in fruit and vegetable products and in wines during the malolactic acid fermentation. Esters of FA have also been shown to retard mould growth on bread (HUHTANEN and GUY, 1984). SHIMUZU et al. (1995) reported that among 9 organic acids commonly used as food additives in Japan, fumaric acid exhibited the strongest growth inhibition action within 160 s of contact with 0.3% (w/v) solution on 20-gram negative bacteria tested. Fumaric acid at a concentration of 1% (w/v) was more effective than acetic or lactic acids in reducing the populations of Listeria monocytogenes by up to 1 log unit and E.coli O157:H7 by up to 1.3 log units on lean beef surfaces (PODLAK et al., 1996). Phosphates have been used widely as texture modifiers, curing agents and to increase water holding capacity and more recently as surface decontaminating agents for meat products (SLAVIK et al., 1994; HWANG and BEUCHAT, 1995). Phosphates have broad-spectrum antimicrobial activity and play an important role on the microbiological shelf life of meat products (MOLINS, 1991). In commercial operations, the prevalence of Salmonella positive broiler carcasses dropped from 25% in control birds to 0.5% in trisodium phosphate (TSP) treated birds and the USDA announced that poultry processors could use a TSP dip to reduce the levels of Salmonella and other bacteria present on the raw poultry (GIESE, 1993). The first claim of successfully reducing salmonellae on processed poultry carcasses was made by BENDER and BROTSKY (LILLARD, 1994). The salmonellae inoculated on the surface of broiler carcasses were reduced by 2 log units after dipping in a 10% TSP solution for 15 min; however salmonellae were recovered from the skin when a water rinse followed the TSP treatment, which may suggest that TSP causes a lethal or sub lethal injury to Salmonella cells. They did not explain how this product removes surface bacteria from poultry, but speculated that the process works partly by removing a thin layer of natural fat coating on poultry skin, allowing bacteria to be washed away more effectively (LILLARD, 1994). Although phosphates have antimicrobial effects, there are limited studies on the effects of phosphate type and concentration for use on refrigerated turkey meat to reduce or eliminate the Salmonella contamination. Nevertheless, conclusive evaluation of the efficacy of the organic acid or...
phosphate treatments has been hindered by the lack of reliable methodology for quantifying the levels of salmonellae on poultry carcasses or products before and after treatment. Since the level of natural salmonellae on poultry meat is unpredictable, it is necessary to evaluate decontamination treatments by using carcasses that have been inoculated with a known number of salmonellae.

Using plate count technique for rapidly and routinely enumerating salmonellae in conjunction with a nalidixic acid resistant (marker) strain of \textit{S.typhimurium}, this article presents the efficacy of lactic acid, fumaric acid, trisodium phosphate and sodium tripolyphosphate dipping treatments for reducing and eliminating the \textit{Salmonella} contamination of turkey breast fillets.

\section*{2 – MATERIAL AND METHODS}

\subsection*{2.1 Turkey breast fillets}

Turkey breast fillets were obtained from a local processing plant, PINAR Integrated Meat and Flour Industry Inc. Fillets were removed from the processing line just before packaging and immediately transported in ice bags to the University laboratories for the experiments. In two experiments, as indicated in the Result and Discussion text as the Experiment 2, refrigerated retail sliced breasts (fillets) were purchased from retail market.

\subsection*{2.2 Microorganism (Bacterial culture)}

\textit{Salmonella typhimurium} (CCM 835) was obtained from Ege University, Department of Biology and maintained on tryptone soy agar (TSA, Oxoid) slant at 4°C and was transferred every 3 months. \textit{S.typhimurium} (CCM 835) was cultured in tryptone soy broth (TSB, Oxoid) at 37°C for 18 h before the experiments.

\subsection*{2.3 Isolation of Nalidixic Acid Resistant (NAR) \textit{S.typhimurium} strain and determination of counting method}

In order to isolate a nalidixic acid resistant (NAR) strain of \textit{S.typhimurium}, 0.1 ml 18 h culture of \textit{S.typhimurium} (CCM 835) was spread over the surface of the prepoured and dried Brilliant Green Agar (BGA, Oxoid) plates containing 10 ppm NA and plates were incubated for 24 h at 37°C (MORRISON and FLEET, 1985; BILGILI S.F., personal communication). After incubation, typical \textit{Salmonella} colonies were picked off the plates and confirmed with gram staining and biochemical tests. Confirmed colonies were subcultured on to BGA containing 100 ppm nalidixic acid by streak method. Then the colonies, which developed on these plates after incubation at 37°C for 24 h, were presumed to be nalidixic acid resistant mutants and were subsequently confirmed by subculturing onto 100 ppm nalidixic acid containing media. Isolated mutants that had the same biochemical characteristics as the parent strain were reconfirmed as the NAR \textit{S.typhimurium} (CCM 835).

A modification of the procedure described by MORRISON and FLEET (1985) was used as the counting method of NAR \textit{S.typhimurium}. One fillet was placed into stomacher bag to which 50 ml of sterile buffered peptone water was added. After 2 min the rinse suspension was transferred to a sterile flask and incubated at 20°C for 2 h to resuscitate sublethally injured cells. After resuscitation, samples (1 ml) of suspension were then inoculated into three different media; in addition BSA supplemented with 100 ppm of nalidixic acid, Brilliant Green Agar, Plate Count Agar and Xylose Lysine Deoxycholate Agar (all supplemented with 100 ppm nalidixic acid) were also examined as counting media but were not selective enough to inhibit growth of non \textit{Salmonella} species that were coming from turkey breast fillets.
2.4 Experiment 1

2.4.1 Inoculation of turkey breast fillets with NAR S.typhimurium

Each breast fillet surface was inoculated by spreading 0.1 ml of NAR S.typhimurium (CCM 835) across the fillet surface using a sterile, bent, glass rod and then allowed to set at room temperature for 20 min for cell attachment (to assure bacterial attachment prior to acid treatment). Then fillet samples were examined for numbers of the NAR S.typhimurium (marker organism) by plating on Bismuth Sulphite Agar containing 100 ppm nalidixic acid after resuscitation. Plates were incubated for 24–48 h at 37°C before counting and recording the number of NAR S.typhimurium (CCM 835) per fillet.

2.4.2 Treatments and storage

Solutions of lactic acid (PURAC FCC80) at 1% and 1.5% (v/v), fumaric acid (Merck, 8.00269.1000) at 0.5% (w/v), trisodium phosphate (Merck, 1.06578) at 5% and 10% (w/v), sodium tripolyphosphate (Merck, 1.06999.1000) at 5% and 10% (w/v) were prepared in tap water. 1% LA, 1.5% LA and 0.5% FA solutions that determined effective in the reduction of microbiological load of turkey breast fillets, without adversely affecting the colour, were used in the treatments (unpublished data). The pH values of acid and phosphate solutions are measured at the time of application with a pH meter as follows: 1% LA (pH = 2.72), 1.5% LA (pH = 2.22), 0.5% FA (pH = 2.70), 5% TSP (pH = 12.68), 10% TSP (pH = 12.92), 5% STPP (pH = 8.90) and 10% STPP (pH = 9.07). Fillets were dipped in 6 L solutions of 1%, 1.5% LA, 0.5% FA, 5%, 10% TSP, 5% and 10% STPP for 1 min then drained on a sanitised tray for 10 min at room temperature. Fillets not treated with acids or phosphates were untreated control samples. After dipping, 3 fillets were packed in a stomacher bag and were transported to a storage room adjusted to 4 ± 1°C and 95% RH for storage.

2.4.3 Enumeration of S.typhimurium (by Microbiological plating)

After 2 h and 24 h following acid or phosphate treatment samples from each treatment were sampled to determine the NAR S.typhimurium (CCM 835) counts or prevalence. 25 g sample was removed aseptically from π of each fillet in the tray, placed in a stomacher bag and 225 ml of sterile 0.1% (w/v) buffered peptone water (Oxoid L37) added. The sample was homogenised for 2 min in a stomacher (Seward Medical, Model 400), and a series of decimal dilutions were prepared. The enumeration of NAR S.typhimurium (CCM 835) was carried out with the plating on BSA supplemented with 100 ppm nalidixic acid after resuscitation. Plates were incubated for 24-48 h at 37°C and the results are presented as the duplicate plates of triplicate samples.

2.5 Experiment 2

In Experiment 2, the effects of organic acid and phosphate immersion treatments on prevalence (elimination) of S.typhimurium (CCM 835) on turkey breast fillets were evaluated with trials. After inoculation of turkey breast fillets with NAR S.typhimurium (CCM 835), fillets were treated with organic acid or phosphate solutions as described in Experiment 1 and then stored at 4 ± 1°C and 95% RH. After 2 h and 24 h following treatment, samples from each treatment were analysed to determine the NAR S.typhimurium (CCM 835) counts and recovery of Salmonella (prevalence of Salmonella), by microbiological plating (as in Experiment 1) and traditional Salmonella detection method, respectively.

2.5.1 Detection of S.typhimurium

Salmonella were detected (observed) using the Turkish Standard (ANONYMOUS, 1996). Each turkey breast fillet was preenriched in 225 ml of Buffered Peptone Water (BPW, Oxoid) at 37°C for 24 h and then 10 and 0.1 ml of preenrichment culture were incubated
at 37°C and 42°C for 24 h, respectively, in 10 ml Selenite Cystine broth (SC, Oxoid) and 10 ml Rappaport Vassiliadias broth (RV, Oxoid) tubes, for selective enrichment. After incubation period from selective enrichment cultures inoculated to selective and differential media (BGA and BSA) by streak method. Plates were incubated for 24-48 h at 37°C and then typical colonies grown on BGA (pink red colonies surrounded by bright red medium) and BSA (black colonies with a black zone and metallic sheen surrounding the colony after 18 hours) were picked off the plates and subcultured into Triple Sugar Iron agar (TSI, Oxoid) AND Lysine Iron agar (LIA, Oxoid). Both media were incubated at 37°C for 18-24 hours (biochemical tests). If the reactions of the TSI and LIA agar were positive, slide agglutination tests were carried out (serological tests).

2.6 Statistical analyses

Data were analysed employing completely randomised factorial design. Analyses of variance was conducted (STAT View) and mean differences were determined using Fisher’s PLSD. The predetermined acceptable level of probability was 5% (P < 0.05) for all comparisons.

3 – RESULTS AND DISCUSSION

3.1 Effect of organic acid immersion treatments on S.typhimurium counts of turkey breast fillets

The effectiveness of dipping of NAR Salmonella typhimurium CCM 835 inoculated turkey breast fillets at a level of 7.7 log cfu per fillet in 1% LA, 1.5% LA and 0.5% FA solutions on the reduction of Salmonella are shown in Table 1. There was a significant difference in S.typhimurium counts after 2 hours between control, 1% LA, 1.5% LA and 0.5% FA treated samples (P < 0.05, table 1). Significantly lower S.typhimurium counts were observed in 1% LA, 1.5% LA and 0.5% FA treated samples as compared to control (P < 0.05). After 2 h dipping treatment the S.typhimurium counts of control, 1% LA, 1.5% LA and 0.5% FA treated turkey breast fillets were 7.8, 5.9, 5.1 and 5.3 log cfu per fillet, showing 1.9, 2.7 and 2.5 log unit reductions respectively (table 1). After 24 h of storage at +4°C the number of S.typhimurium increased rapidly in the samples treated with each of the acid solutions (Table 1). There was no change (increase or reduction) in S.typhimurium count of control with an initial count of 7.8 log cfu per fillet after 24 h at +4°C. In 1% LA and 0.5% FA treated samples the number of S.typhimurium reached 7.2 and 7.1 log cfu per fillet after 24 h + 4°C indicating 1.3 and 1.8 log unit increases, respectively. But this count remained at 6.1 log unit level in the samples treated with 1.5% LA indicating a 1.7 log unit lower count than those of control samples, after 24 h at +4°C (Table 1).

XIONG et al. (1998) evaluated aqueous solutions of 1% and 2% LA in pre chill spraying for reducing S.typhimurium attached on chicken skins. Chicken skins were inoculated with S.typhimurium and then sprayed with the selected chemical solutions for 30 sec at 206 kPa and 20°C. The results showed that the numbers of Salmonella on the chicken skins after the chemical spraying were significantly lower than those without spray (P<0.05). The LA reduced Salmonella with the initial count of 7.0 log cfu per ml by 2.2 log unit. Again in another study pre chilled chicken carcass skins were inoculated with S.typhimurium then sprayed with 2% LA at 25, 40, 55 and 70°C, the treatments reduced S.typhimurium by 1.0, 1.4, 1.5 and 1.3 log, respectively (XIONG et al., 1998). The results obtained in this study from the standpoint of immediate effect of LA on S.typhimurium counts of turkey breast fillets are in parallel with the data presented in the literature. Although there is no published data on the effect of FA on S.typhimurium the results obtained in this study showed that FA treatment as poultry decontaminating treatment is as effective as LA treatment.
Table 1

<table>
<thead>
<tr>
<th>Storage Period (Hour)</th>
<th>S. typhimurium count (log CFU per fillet)</th>
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<tbody>
<tr>
<td></td>
<td>C&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>2</td>
<td>7.8 ± 0.5&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>24</td>
<td>7.8 ± 0.2&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

1. Each value in the table is the mean ± standard deviation of three samples. Different letters within the same row are significantly different (P > 0.05).

C: Control, LA: dipped in lactic acid solution, FA: dipped in fumaric acid solution.

3.2 Effect of phosphate immersion treatments on S. typhimurium counts of turkey breast fillets

There were no significant difference (P > 0.05) in S. typhimurium count between control and 5% STPP treated samples, but significantly lower counts were observed in 5%, 10% TSP and 10% STPP treated samples as compared to control after 2 h of dipping treatment (Table 2). S. typhimurium counts of control and 5%, 10% TSP and 10% STPP treated turkey breast fillets were 7.2, 5.8, 3.7, 7.2 and 4.0 log cfu per fillet, respectively (Table 2). After 2 h dipping treatment Salmonella counts of 5%, 10% TSP and 10% STPP treated samples were 1.4, 3.5 and 3.2 log unit lower than those of control samples increased 0.8 log units and reached 8.0 log cfu per fillet. In 10% TSP and 10% STPP treated samples the number of S. typhimurium reached to a level of 6.3 and 7.8 log cfu per fillet indicating 2.6 and 3.8 log unit increases, respectively. These results indicate that storage period was effective on S. typhimurium counts and the most effective treatment in lowering the Salmonella count was dipping in 10% TSP. Kim et al. (1994) investigated a 15 sec immersion of chicken skins in 10% TSP solution. A 1.7 and 2.2 log unit reduction of Salmonella was found on chicken skins treated with TSP solution at temperatures of 10°C and 50°C, respectively. Lillard (1994) treated inoculated chicken skin carcasses by immersing them in a 10% TSP solution for 15 min, and a 2 log unit reduction of Salmonella was subsequently observed. Similarly, Slavik et al. (1994) conducted trials in which post chill chicken carcasses were dipped in a 10% TSP solution for 15 sec and they found that the levels of Salmonella on chicken carcasses were reduced in the range of 1.6–1.8 log unit. Hwang and Beuchat (1995) investigated seven chemicals, including TSP, sodium tri polyphosphate, monosodium phosphate, sodium acid pyrophosphate, sodium hexametaphosphate, LA, and NaOH, for their effectiveness in reducing pathogenic populations on chicken skins. They found that the Salmonella on chicken carcasses were reduced in the range of 1.6–1.8 log unit. Whyte et al. (2001) investigated the effects of dipping in a 10% TSP solution (pH = 12) for 15 s broiler carcasses during processing. The TSP treatment resulted in higher reductions of log 1.95 and 1.86 per g for E. coli and Enterobacteriaceae, respectively. Significantly, Salmonella was not detected in any of the TSP treated carcasses, while 1.92 log and 1.04 log per g were found in control and water dipped samples, respectively. Xiong et al. (1998) evaluated aqueous solutions of 5% and 10% TSP in pre chill spraying for reducing S. typhimurium attached on chicken skins. Chicken skins were inoculated with S. typhimurium and then sprayed with the selected chemical solutions for 30 sec at 206 kPa and 20°C. The results showed that the numbers of Salmonella on the chicken skins after the chemical spraying were significantly lower than those with-
out spray ($P<0.05$). The TSP reduced *Salmonella* with the initial count of 6.9 log cfu per ml by 2.1 to 2.2 log units. Again in another study pre chilled chicken carcass skins were inoculated with *S.typhimurium* and sprayed with 10% TSP. The numbers of *S.typhimurium* in TSP spray treatments with different temperatures were reduced by 1.2 to 1.9 log compared to the water spray control (XIONG et al. 1998), YANG et al. (1998) applied antimicrobial spray of 10% TSP using a modified inside-outside birdwasher to reduce *S.typhimurium*. Each chicken carcass was inoculated by spraying the outside and inside of each carcass with *S.typhimurium* at 10^5 cfu per carcass. The inoculated carcasses then were passed through the bird-washer and sprayed with 10% TSP at 35°C at a pressure of 413 kPa for 17 s and the treatment reduced the *Salmonella* on the chicken carcasses by approximately 2 log cfu per carcass. Results obtained in this study indicate that phosphate solutions caused somewhat similar or slightly higher reductions on *S.typhimurium* than the reductions reported. The inconsistencies could be attributed to a number of variables including different types of meat, method of phosphate application (dipping or spraying), different experimental conditions (temperature-time), different *S.typhimurium* strain (initial number) and different counting and isolating methods.

Table 2

<table>
<thead>
<tr>
<th>Storage Period (Hour)</th>
<th><em>S.typhimurium</em> count (log CFU per fillet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C(^a)</td>
</tr>
<tr>
<td>2</td>
<td>7.2 ± 0.3(^a)</td>
</tr>
<tr>
<td>24</td>
<td>8.0 ± 0.0(^a)</td>
</tr>
</tbody>
</table>

1. Each value in the table is the mean standard deviation of three samples. Different letters within the same row are significantly different ($P > 0.05$). C: Control, TSP: dipped in trisodium phosphate solution, STPP: dipped in sodium tripolyphosphate solution.

### 3.3 Effects of organic acid and phosphate immersion on the incidence of *S.typhimurium* on turkey breast fillets

The results of the trials in order to determine the effect of lactic acid and trisodium phosphate solutions on the elimination of inoculated *S.typhimurium* on turkey breast fillets were presented in tables 3 and 4. While there was only one *Salmonella* positive sample out of three fillets with an initial inoculum of 3.1 log cfu *S.typhimurium* per fillet dipped in 1.5% LA solution, no *Salmonella* positive sample was observed in three samples dipping in 10% TSP solution, 2 hours after dipping. All three samples were *Salmonella* positive 2 hours after dipping the fillets with an initial inoculum of 4.1 log cfu *S.typhimurium* per fillet in 10% TSP solution. According to table 3 the only *Salmonella* negative samples were the 10% TSP dipped samples with an initial inoculum of 3.1 log cfu *S.typhimurium* per fillet after 24 hours storage at +4°C. Table 4 shows the results of the LA and TSP dipping on the elimination of *Salmonella* at two different levels (2.6 and 3.6 log cfu per fillet) of initial inoculum slightly lower than the former experiment. All the samples dipped in 1.5% LA and 10% TSP with an initial inoculum level of 2.6 log cfu per fillet, and dipped in 10% TSP with an initial inoculum level of 3.6 log cfu per fillet were found to be *Salmonella* negative after 2 and 24 hours storage at +4°C (table 4). The data presented in table 3 and 4 clearly indicates that dipping turkey breast fillets in 10% TSP solution for 1 min eliminates *S.typhimurium* inoculated at a level of approximately 10^2 cfu per fillet. This finding is in good accordance with the results presented in table 2, which cause similar immediate reductions (3.5 log unit) in the initial level of inoculated *S.typhimurium* when turkey breast fillets were dipped in 10% TSP solution for 1 minute. Similarly, LILLARD (1994) reported that there were no *Salmonella* positive rinsing liquid and skin homogenate samples after dipping 10^5 cfu nalidixic acid resistant *S.typhimurium* inocu-
lated 9 chicken carcasses in 15 min 10% TSP solution (pH = 11.3-12.6). *Salmonella* are mainly killed or injured because of chemical interactions between extremely high pH TSP and cell wall elements.

The effects of dipping in organic acids (LA, FA) and phosphates (TSP, STPP) on *Salmonella* were different. This is reasonable since the two treatments have different mechanisms of action. The TSP probably has a detergent effect, making clumps of the cells split and loosen from the skin, while the bactericidal effects of LA are due to the ability of the undissociated acid to penetrate the bacterial cell membrane and acid effect. Apart from the present investigation, there have been no known published studies on the susceptibility of *S.typhimurium* to fumaric and lactic acid, and phosphates (TSP, STPP) in turkey meat. The bactericidal activities of LA and FA were of a similar magnitude. The most effective treatment among the four treatment used in this study to eliminate *S.typhimu-

Table 3

<table>
<thead>
<tr>
<th>Storage Period (Hour)</th>
<th>Low inoculum&lt;sup&gt;a&lt;/sup&gt;</th>
<th>High inoculum&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.5% LA 10% TSP</td>
</tr>
<tr>
<td></td>
<td>log cfu/fillet</td>
<td>Qualitative/fillet&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>2</td>
<td>2.7 ± 0.1</td>
<td>1/3</td>
</tr>
<tr>
<td>24</td>
<td>3.0 ± 0.1</td>
<td>3/3</td>
</tr>
</tbody>
</table>

<sup>a</sup> 3.1 log CFU/fillet.
<sup>b</sup> 4.1 log CFU/fillet.
<sup>c</sup> Each value in the table is the mean standard deviation of three samples.
<sup>d</sup> C: Control, LA: dipped in lactic acid solution, TSP: dipped in trisodium phosphate solution.

Table 4

<table>
<thead>
<tr>
<th>Storage Period (Hour)</th>
<th><em>S.typhimurium</em> /fillet&lt;sup&gt;a&lt;/sup&gt;</th>
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<tbody>
<tr>
<td></td>
<td>Low inoculum&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>C</td>
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<td>2</td>
<td>3/3</td>
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<td>24</td>
<td>3/3</td>
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</tbody>
</table>

<sup>a</sup> Number of *Salmonella* positive sample of three samples.
<sup>b</sup> C: Control, LA: dipped in lactic acid solution, TSP: dipped in trisodium phosphate solution.
<sup>c</sup> 2.6 log CFU/fillet.
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