# Effect of Liquid Smoke Extracts on Frankfurters Inoculated with *Listeria monocytogenes*

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## Story in Brief

*Listeria monocytogenes* has been troublesome for many ready-to-eat meats, especially hotdogs which have had the highest incidences of *Listeria*. The objective of this study was to examine the effect of liquid smoke flavoring extracts on the inhibition of *L. monocytogenes* on hotdogs. Hotdogs were dipped for 2 minutes in liquid smoke extracts (controls were dipped in sterile water) and vacuum-sealed with an inoculum ($10^7$or $10^8$ CFU/bag) of a four strain "cocktail" of *L. monocytogenes*. Samples were heated in a temperature-controlled water bath for 1 minute at 73.9$^o$C (165°F) and stored under abuse conditions at 10°C (50$^o$F) and plated weekly for four or six weeks. When processed with heat alone, the results showed approximately a 2-log reduction (List-A-Smoke) or 2.5-log reduction (Zesti Advantage B) of *Listeria* in which surviving cells recovered and grew to higher levels than were present initially within one week. No differences was observed in *Listeria* levels at the point of pasteurization for products dipped, or not, in List-A-Smoke but were obtained for products treated with Zesti Advantage B. For hotdogs dipped in smoke extracts alone, *L. monocytogenes* slowly declined over 3 to 6 weeks to show approximately a 1.5-log reduction from initial levels whereas product that was dipped and pasteurized demonstrated a > 3-log reduction in spite of the high residual level of *Listeria*. The data shows that liquid smoke extract may provide both growth inhibition and bactericidal activities for *L. monocytogenes* on hotdogs that may be contaminated during postprocess handling.

Key Words: *Listeria monocytogenes,* Liquid smoke, Frankfurters, Lactate, and Diacetate

## Introduction

*Listeria monocytogenes* is a Gram-positive foodborne pathogen causing approximately 2,500 serious illnesses and 500 deaths in the U.S. every year. Recalls, illnesses, and deaths due to the consumption of *Listeria* contaminated food products have been reported over the last few years (Glass et al.1999). The significance of listeriosis demonstrates that there is a need for controlling *Listeria* in food processing plants especially in those producing ready-to-eat (RTE) products. According to FSIS Directive 10,240.3 (2002), various RTE meat products are placed in high/medium or low risk categories, and high-risk products can be moved to a low-risk category if a processor uses a postprocess lethality step or antimicrobial chemicals to control *Listeria.* The USDA-FSIS final rule (June 6, 2003) also identified three alternatives for processors of RTE meat products, whereby Alternative 1 had the least USDA product testing and Alternative 3 processors had the most. Alternative 1 indicated a process that contained both a postprocess lethality step and antimicrobials for controlling *L. monocytogenes;* Alternative 2, a postprocess lethality step or antimicrobials; Alternative 3, control of *L. monocytogenes* by sanitation alone. Therefore, the incentive to do something pro-active to move out of the Alternative 3 category was a decrease in regulatory agency testing of product.

Traditional smoking of meat and meat products is a well known preservation technique and has been shown to inhibit the growth of *L. monocytogenes* (Martinez et al. 2004). Currently food industries are working on the development of new applications of smoke condensates that have antimicrobial and antioxidant properties. The main advantages of liquid smoke is that very little equipment is needed, the application is fast, cheap, and effective. However, the efficacy of antimicrobial properties needs to be demonsrated on various targeted products and when applied in various ways.

## Materials and Methods

Four strains of *Listeria monocytogenes* were selected for use as an inoculum mixture. Hotdogs were given three different treatments: smoke extract dip treatment alone (2 min), heat alone (165ºF for 1 min) and smoke plus heat treatment. Two different brands of liquid smoke extracts (List-A-Smoke$^{Tm}$ and Zesti Advantage B$^{Tm}$, Mastertaste Inc.) were used. Hotdogs were obtained from retail purchase and boiled for 5 min to eliminate any leachable ingredients. After boiling they were chilled and allowed to dry. Samples were dipped in smoke solution (List-A-Smoke or Zesti-B) for 120 sec. Controls received no smoke extract treatment. Hotdog samples were then placed in vaccum bags into which 1 ml of inoculum mixture of 4 strains of *L. monocytogenes* was added. The bags were vacuum sealed and these packages were chilled and stored at an abuse temperature of 10ºC (50ºF). Samples were plated each week for 4 to 6 wks.

Data are expressed as the means of triplicate replications of paired samples (i.e., $n$=6) ± SD. Statistical comparison of the various treatments at one week and beyond was performed by one way analysis of variance (Sigma Stat 3.0, SPSS, Chicago, IL). Data were considered signicant when their computed probalities were less than 0.05 ($P < 0.05$).

Because of the observation of growth of *Listeria* on our retail hotdogs that were not smoke treated, we examined four brands of retail hotdogs that contained lactate and diacetate as growth inhibitors of *Listeria* when inoculated with our *L. monocytogenes* mixture. Hotdogs were briefly rinsed with sterile chilled water and placed in vacuum bags to which 1 ml of inoculum mixture of four strains of *L. monocytogenes* were added. Finally, the bags were vacuum sealed and then chilled and stored at 1.7ºC (35ºF). Samples were then plated each week for 6 wks.

## Results and Discussion

In two trials with liquid smoke extracts, List-A-Smoke (Fig. 1) and Zesti-B (Fig. 2), hotdogs treated with heat alone showed recovery of residual levels of *L. monocytogenes*. With samples treated with smoke extract alone, both smoke extracts demonstrated approximately a 2-log reduction of *Listeria* after 4 week's storage (Zesti-B showed a 2-log reduction after only 1 week). The inhibitory effect of the smoke extracts was enhanced when combined with a heat pasteurization step, and especially with Zesti-B (Fig. 2) whereby no detectable *Listeria* was detected by the 3rd week and demonstrated a greater than 7-log reduction (in combination with 1 min pasteurization at 165ºF). These data point to the potential ability of liquid smoke extracts to not only suppress growth of *Listeria* during shelf life, but also render a reduction in *Listeria*, should product be contaminated during packaging.

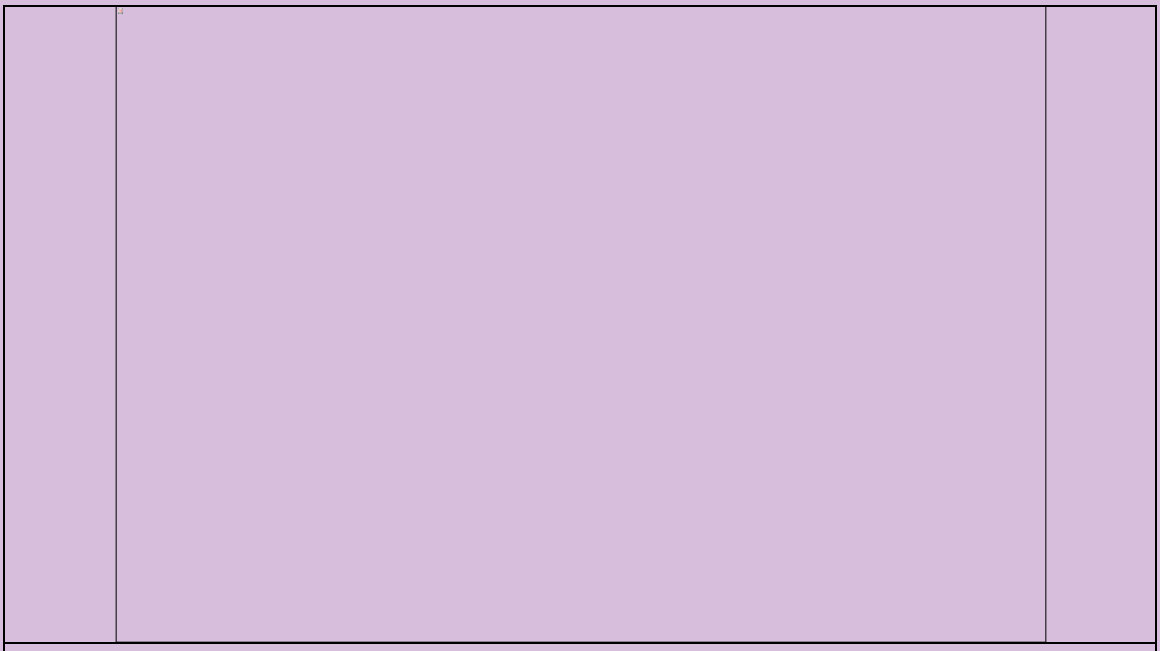

Figure 1. Hotdogs treated with either Lista-Smoke™ alone, heat treatment alone (1 min @ 165$^{o}$F), or Lista-Smoke™ in combination with heat (1 min @ 165$^{o}$F). Hotdogs were inoculated with a 4-strain mixture of *L. monocytogenes* and held at 50$^{o}$F (abuse temperature) for shelf-life testing. All three treatments were significantly different ($P$<0.05).

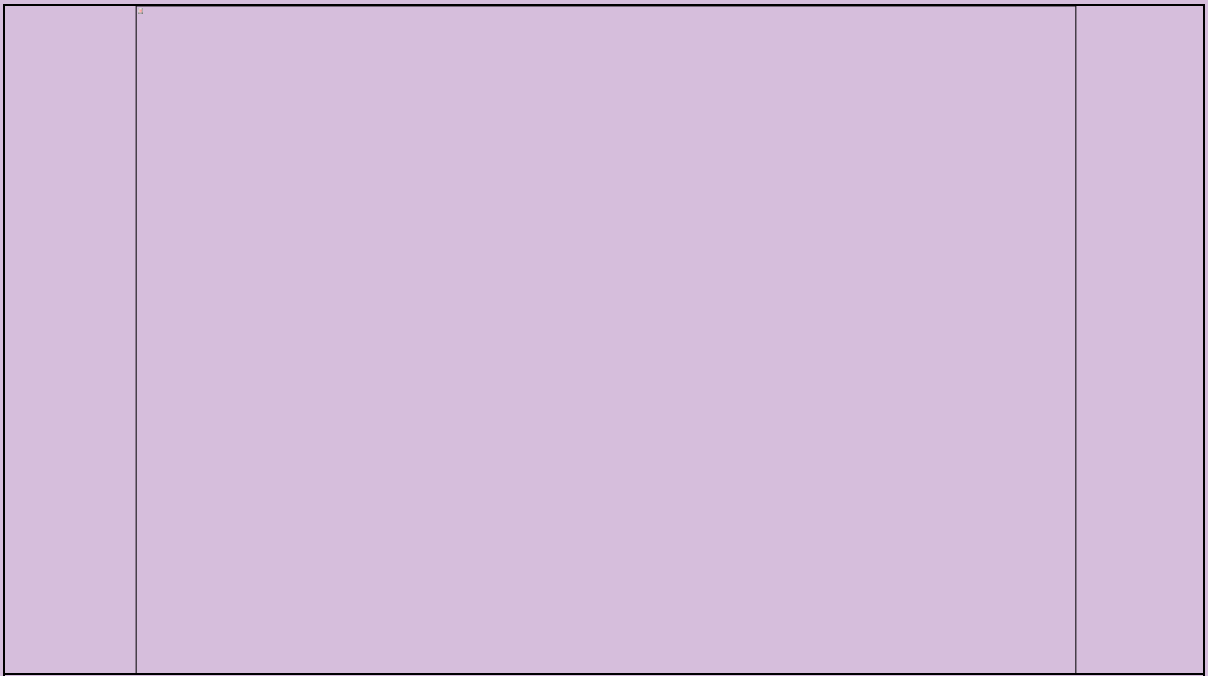

Figure 2. Hotdogs treated with either Zesti-B™ alone, heat treatment alone (1 min @ 165$^{o}$F), or Zesti-B™ in combination with heat (1 min @ 165$^{o}$F). Hotdogs were inoculated with a 4-strain mixture of L. monocytogenes and held at 50$^{o}$F (abuse temperature) for

shelf-life testing. All three treatments were significantly different ($P<0.05$).

Based on the results obtained with growth of *Listeria* on the heat treated products in Figs. 1 and 2, we performed inoculated testing of four brands of retail franks that contain lactate and diacetate, specifically to prevent the growth of potential *Listeria* contamination. This would allow the manufacturers to comply with USDA-FSIS regulations allowing for products to be classified into lower-risk categories if manufactured with *Listeria*-inhibiting ingredients. However, when we inoculated such products with a low level of *L. monocytogenes* (i.e., ~15 CFU) and incubated them at 35°F, they quickly rose to much higher levels indicating ineffective inhibition of *Listeria* and demonstrating the need for *Listeria* control on such products (Fig. 3).

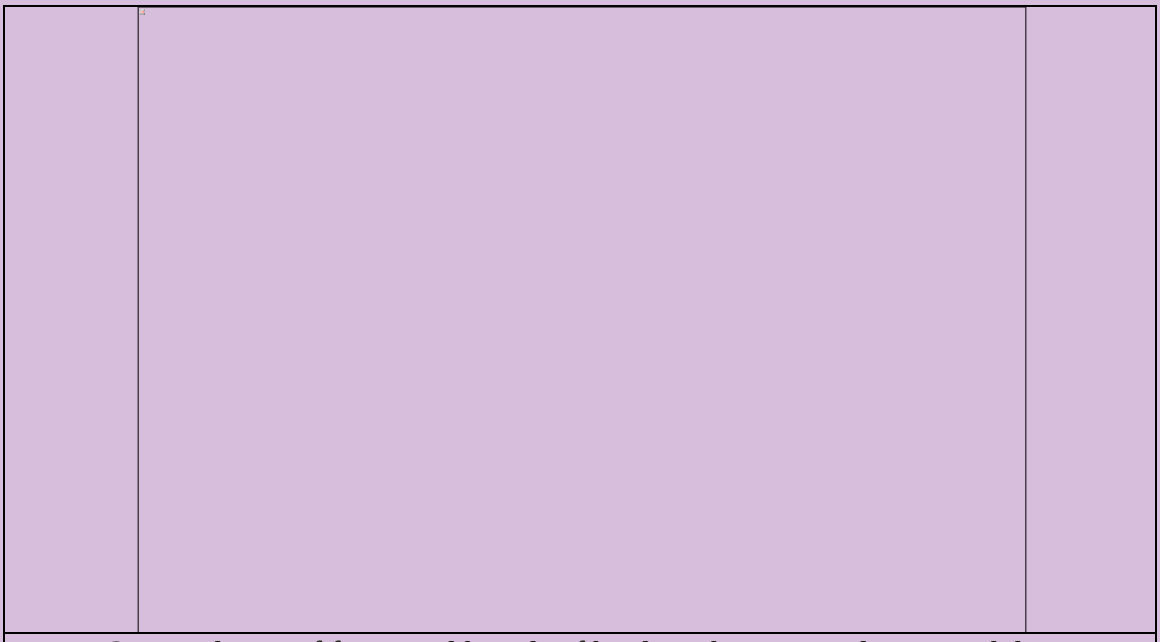

Figure 3. Inoculation of four retail brands of hotdogs that contain lactate and diacetate with low-level inoculum mixture (~15 CFU) of four strains of *L. monocytogenes*, incubated at 35°F, and tested weekly for level of *L. monocytogenes*. Each curve represents the mean of six replications.

Current use of lactate/diacetate may not sufficiently retard the growth of contaminating *Listeria* on RTE meat products. Currently, when processors implement pre- and post-package pasteurization equipment for reduction of *Listeria* on RTE meats, they are required to demonstrate validation of the process showing the reduction with inoculated pack studies. However, similar use of lactate/diacetate to retard the growth of *Listeria* on RTE has not been met with the same validation requirements, and most processors rely on documentation of the seminal work with lactate/diacetate as an effective growth inhibitor of *Listeria*. Liquid smoke extracts (i.e., Lista-A-Smoke, Zesti-B) may provide inhibition of growth or reduction of contaminating *Listeria* on RTE meat products such as hotdogs as well as large deli products in combination with pre- or post-package pasteurization.

## Literature Cited

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