

# Effect of Freezing, Thawing Method, and Aerobic Storage on the Fate of *Listeria monocytogenes* during Home Storage of Frankfurters

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## ABSTRACT

**Introduction:** Although surveys have shown that consumers regularly store unopened frankfurter packages in home freezers, little information is available regarding the fate of *Listeria monocytogenes* during home storage after thawing. When available, instructions recommend thawing in the refrigerator and discourage countertop thawing, while instructions for microwave defrosting are consistently absent.

**Purpose:** This study examined the effects of antimicrobials, storage time, freezing, thawing method and subsequent home storage on *L. monocytogenes* on frankfurters.

**Methods:** Packages of inoculated (2 log CFU/cm<sup>2</sup>) frankfurters (8 per package, 3 per treatment), formulated without antimicrobials or with 1.5% potassium lactate plus 0.1% sodium diacetate, were stored at 4°C for 6 or 30 d, then frozen (-15°C; 10, 30, or 50 d). Products were thawed under refrigeration (7°C, 24 h), on a countertop (23 ± 2°C, 8 h), or by microwave defrosting (220 s, 2459 MHz, 1100 watts, followed by 120 s holding). After thawing and during subsequent aerobic storage (7°C; 3, 7, and 14 d), bacterial populations were enumerated on PALCAM agar and tryptic soy agar plus 0.6% yeast extract.

**Results:** Antimicrobial ingredients completely inhibited (P <0.05) growth of *L. monocytogenes* before freezing and during the entire aerobic storage period (7°C, 14 d) following thawing. For control frankfurters, length of storage before freezing (4°C; 6 or 30 d) resulted in different pathogen levels on unfrozen product (2 or 4 log CFU/cm<sup>2</sup>, respectively), while freezing (10, 30, or 50 d) reduced counts by <1.0 log CFU/cm<sup>2</sup>. Changes in pathogen counts following thawing were -1.8 to +0.2 log CFU/cm<sup>2</sup>, with microwaving resulting in the largest reductions. *L. monocytogenes* populations on control samples, regardless of thawing method, were similar at 7 and 14 d of aerobic storage (3-4 and 5 log CFU/cm<sup>2</sup>, respectively). In general, the fate of *L. monocytogenes* during aerobic storage, following thawing, was not influenced by freezing or by thawing method.

**Significance:** Microwave defrosting should be included in thawing recommendations. Antimicrobials present in frankfurter formulations inhibit growth of *L. monocytogenes*, diminishing the negative impact of extended storage of sealed and/or opened packages.

## OBJECTIVES

The objectives of this study were to evaluate the effects of storage, freezing, and thawing method on *L. monocytogenes* on frankfurters formulated with or without potassium lactate (1.5%) and sodium diacetate (0.1%).

## INTRODUCTION

Frankfurters are in continuous demand and in 2006, frankfurter retail sales exceeded \$1.5 billion in the U.S. alone (Anonymous, 2006). Nevertheless, inadequately reheated frankfurters are included among the food products of most concern regarding human listeriosis (CDC, 2005). The incidence of foodborne illnesses may be reduced by simply engaging consumers and equipping them with the information needed to avoid improper handling of food products. As an example, freezing is recommended to preserve quality and to minimize food safety concerns associated with frankfurters, and recent surveys indicate that unopened packages of frankfurters are regularly stored in home freezers (Porto et al., 2004). However, scientifically validated thawing recommendations are not available, and thawing instructions are consistently absent from frankfurter package labels. When available, instructions typically recommend thawing under refrigeration and discourage countertop thawing, and tend to ignore microwave defrosting methods.

## MATERIALS AND METHODS

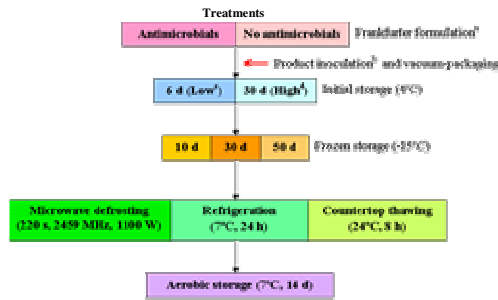
### Chemical, physical, and microbiological analyses

On the day of product inoculation (day-0) and throughout storage:

- pH and a<sub>w</sub> values
- Microbial counts
  - Samples (3 per treatment) placed in 50 ml of maximum recovery diluent (MRD; 0.85% NaCl and 0.1% peptone)
  - Vigorously shaken (30x, 1 ft arch) and serially diluted (0.1% buffered peptone water)
  - Appropriate dilutions plated (in duplicate) onto PALCAM and tryptic soy agar + 0.6% yeast extract (TSAYE)
  - Incubated (30°C for 48 h, and 24 ± 2°C for 72 h, respectively), and bacterial colonies enumerated

### Statistical analysis

- Two replications
- Data were analyzed using ANOVA in mixed model procedure of SAS<sup>®</sup> (version 9.1, SAS Institute, Cary, NC)



- \*Pork, beef, water, sodium chloride, dextrose, dry mustard, corn syrup solids, polyphosphate, sodium nitrite, sodium erythorbate, paprika, onion powder, garlic powder, coriander white pepper, formulated with or without antimicrobials (1.5% potassium lactate plus 0.1% sodium diacetate).
- \*Ten strain composite of food, environmental, and human clinical *L. monocytogenes* isolates (Fuguet et al., 2006) was prepared as described by Lanou et al. (2006) and applied (200µl) to each frankfurter. Target inoculum level: 2 log CFU/cm<sup>2</sup>.
- \*Low initial level of *L. monocytogenes* (2 log CFU/cm<sup>2</sup>) on frankfurters after 6 d at 4°C, and just before freezing.
- \*High initial level of *L. monocytogenes* (4 log CFU/cm<sup>2</sup>) on frankfurters after 30 d at 4°C, and just before freezing.

## RESULTS

### Antimicrobials

- Potassium lactate (1.5%) plus (0.1%) sodium diacetate inhibited proliferation of *L. monocytogenes* on frankfurters throughout:
  - Refrigerated storage (4°C, 6 or 30 d) (Fig. 1)
  - Aerobic storage (7°C, 14 d) after samples were thawed

### Freezing

- To examine the impact of freezing on *L. monocytogenes*, frozen product was placed directly in MRD for microbiological analysis
- The only populations affected by freezing were those (Fig. 2):
  - Inoculated on control frankfurters formulated without antimicrobials
  - Frozen during logarithmic growth phase

### Thawing method

- Regardless of product formulation or initial storage conditions (6 vs. 30 d, 4°C), microwave defrosting resulted in the largest reductions in *L. monocytogenes* during thawing (Fig. 3)
- Overall, pathogen counts were similar after thawing under refrigeration (7°C, 24 h) or thawing on a countertop (23 ± 2°C, 8 h); in general, *L. monocytogenes* did not grow on frankfurters without antimicrobials during refrigerated or countertop thawing treatments (Fig. 3)
  - As an exception, populations which were frozen at 30 d after inoculation and had allowed pathogen growth (high initial population at freezing) did grow (0.25 ± 0.30 log CFU/cm<sup>2</sup>) during refrigerated thawing

### Aerobic storage

- L. monocytogenes* grew on frankfurters without antimicrobials after 3 d of storage (7°C; Fig. 4)
- All populations on frankfurters without antimicrobials increased by 1.5 ± 0.2 log CFU/cm<sup>2</sup> at day-7 of aerobic storage (Fig. 4), although pathogen counts were 1-2 log-cycles lower on frankfurters frozen 6 d after inoculation compared to those on frankfurters which were held longer (30 d, 4°C) before freezing (3.3-3.6 vs. 4.4-5.3 log CFU/cm<sup>2</sup>, respectively)
- All pathogen populations were similar (5.8 ± 0.4 log CFU/cm<sup>2</sup>) by 14 d of storage (Fig. 4)

## REFERENCES

- Anonymous. 2006. Available at: <http://www.fda.gov/oc/ohrt/060404.html>, Accessed 28 December 2006.
- CDC (Centers for Disease Control and Prevention). 2005. Available at: <http://www.cdc.gov/od/ohrt/050404.html>, Accessed 12 September 2006.
- FSIS (Food Safety and Inspection Service). 2006. Available at: [http://www.fsis.usda.gov/Fact\\_Sheets/Bases\\_for\\_Handling\\_Food\\_Safety/060506.html](http://www.fsis.usda.gov/Fact_Sheets/Bases_for_Handling_Food_Safety/060506.html), Accessed 21 June 2007.
- Fuguet, E., E. Fortes, C. Knooka, and M. Weidmann. 2006. *J. Food Prot.* 69:2929-2938.
- Lanou, A., I. Geornaras, P. A. Kendall, K. E. Belk, J. A. Scanga, G. C. Smith, and J. N. Sofos. 2006. *J. Food Prot.* 70:378-385.
- Porto, A. C. S., J. E. Call, and J. B. Luchansky. 2004. *J. Food Prot.* 67:71-76.

Fig. 1

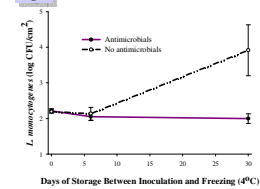
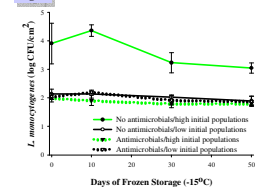


Fig. 2



Days of Storage Between Inoculation and Freezing (4°C)

Days of Frozen Storage (-15°C)

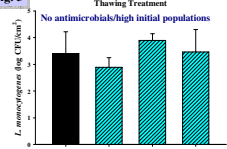
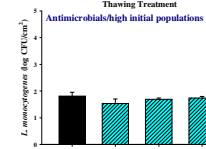
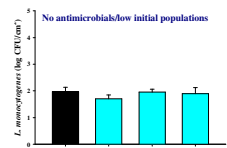
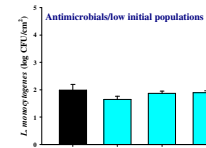


Fig. 3

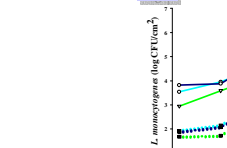
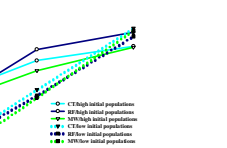


Fig. 4



## CONCLUSIONS

- Antimicrobials within the formulation suppressed the growth of *L. monocytogenes* during vacuum-packaged (4°C, 30 d) and aerobic storage (7°C, 14 d) of frankfurters.
- In the absence of inhibitory agents, *L. monocytogenes* populations grew during vacuum-packaged storage (4°C, 30 d; 2.0 log cycles) and aerobic storage (7°C, 7 or 14 d; 1.5 or 2.0-4.0 log cycles, respectively).
- Freezing (-15°C, 10, 30, or 50 d) had little effect on the fate of *L. monocytogenes*.
- Thawing method did not influence the fate of *L. monocytogenes* during subsequent home storage, although microwave defrosting resulted in slightly lower pathogen populations compared to other treatments/controls, and thawing under refrigeration permitted modest growth on frankfurters without antimicrobials (frozen 30 d after inoculation).
- These data indicate that the addition of antimicrobial ingredients to commercial frankfurters may negate health risks associated with improper product thawing and/or holding.
- After purchasing older frankfurters devoid of inhibitory agents, consumers should freeze unopened packages immediately and discard uneaten product within 3 d of thawing and/or opening.

This work was supported by the National Integrated Food Safety Initiative of the United States Department of Agriculture Cooperative State Research, Education and Extension Service (agreements 2004-51110-02160 and 2005-51110-03278), and by the Colorado State University Agricultural Experiment Station.

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