Listeria monocytogenes Destruction During Drying and Storage of Beef Jerky Treated with Marinades

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SUMMARY

Presence of *Listeria monocytogenes* in ready-to-eat meat products such as jerky may lead to foodborne illness. This study evaluated the influence of various pre-drying treatments on inactivation of acid-adapted or nonadapted *L. monocytogenes* in beef jerky during preparation, drying and storage. Dipping meat slices into 1% Tween 20, and 5% acetic acid prior to traditional marinade (TM), or using a double amount of modified TM (1.2% sodium lactate, soy sauce with 5% ethanol, and 9% acetic acid) resulted in significantly *(P<0.05)* higher reductions of bacterial populations during drying and storage compared to TM alone or control, regardless of acid adaptation.

Key Words: *Listeria monocytogenes*, Jerky, Drying, Storage.

INTRODUCTION

Listeria monocytogenes is ubiquitous in nature and when ingested, may cause fatal diseases such as meningitis, septicemia or premature births. A recent report (Levine et al., 2001) by the Food Safety Inspection Service of the U. S. Department of Agriculture (FSIS/USDA) indicated that for the period of 1990 to 1999, cumulative prevalence of L. monocytogenes in jerky produced in federally inspected plants was 0.52%. Currently, FSIS applies a "zero-tolerance" policy for *L. monocytogenes* in ready-to-eat meat products including jerky. Products that are not in compliance with this policy are considered adulterated under the provisions of Federal Meat Inspection Act (21 U. S. Code, 601 (m).

The recent *Salmonella* and *E. coli* O157:H7 outbreaks linked to jerky consumption (CDC, 1995; Eidson et al., 2000; Keene et al., 1997) have increased interest in evaluating the efficacy of jerky processing, especially when prepared in home-type dehydrators, to inactivate foodborne pathogens (Harrison and Harrison, 1996, 2001). As a response to the problem, FSIS has suggested cooking to 160°F (71.1°C) before drying to reduce or eliminate pathogens. However, pre-heating of meat and/or drying of jerky at high temperatures for extended periods of time may result in a product that differs from traditional jerky and, thus, it may reduce consumer acceptability. Use of chemical intervention strategies as pre-drying treatments, however, has not been studied adequately. Such interventions may be a viable option to avoid severe heat treatments and may provide residual antimicrobial effects during product storage. Potential chemical interventions include organic acids (e.g., acetic acid), ethanol, lactates, and food grade surfactants (e.g., polysorbates). Therefore, the objective of the present study was to evaluate the effectiveness of various chemical-based pre-drying treatments (modified marinades) to control acid-adapted or nonadapted *L. monocytogenes* during preparation, drying, and storage of whole muscle beef jerky.

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MATERIALS AND METHODS

Preparation of inoculum.

A five-strain composite of *L. monocytogenes* was used for inoculating beef slices. These strains were LM101 (sausage), LM103 (sausage), N-7143 (sausage), N-7144 (sausage), and TB2000 (turkey breast). Each strain was grown in glucose-free trypticase soy broth for nonacid adapted cells or in glucose-free TSB with 1% added glucose for acid-adapted cells for 24 h at 86°F (30°C) prior to combining, centrifuging and diluting to a final level of 7.0 log CFU/ml.

Inoculation of meat slices

Vacuum packaged and frozen/thawed beef slices (0.2 x 3.4 x 1.6 inch (0.6 x 8.7 x 4.0 cm)) were placed on trays and surface inoculated with 0.5 ml of the *L. monocytogenes* inoculum on each side at 15 min intervals for bacterial attachment. The resulting level of inoculum was approximately 6.2 log CFU/cm^2.

Pre-drying marinade treatments and drying

Inoculated meat slices were subjected to the following pre-drying marinade treatments for 24 h at 40°F (4°C): 1) no treatment (C), 2) traditional marinade (for 1.0 kg of meat: 60 ml soy sauce, 15 ml Worcestershire sauce, 0.6 g black pepper, 1.25 g garlic powder, 1.5 g onion powder, and 4.35 g old hickory smoked salt (Andress and Harrison (1999) (TM), 3) modified marinade (for 1.0 kg of meat: 120 ml of soy sauce containing approximately 4.7-5.0 % ethanol as preservative, 30 ml of Worcestershire sauce, 0.6 g black pepper, 1.25 g garlic powder, 1.5 g onion powder, 4.35 g smoke-flavored salt, 3.6 ml food grade sodium-L-lactate, and 16 ml of glacial acetic acid to adjust the pH to 3.0) (MM), 4) dipped in 5% acetic acid for 10 min, then in TM (AATM), and 5) dipped in 1% Tween 20 for 15 min, then in 5% acetic acid for 10 min, followed by TM (TWTM). Marinated meat slices were dried at 140°F (60°C) for 10 h in home-type dehydrators. The temperature of the dehydrators and surface temperature of meat slices were monitored using thermocouples and recorded with real-time data recording software. After drying, the jerky strips were held in the dehydrators overnight as recommended (Andress and Harrison, 1999), and then placed into 24-oz sterile plastic bags for storage at ambient temperature 77°F (25°C).

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Analysis

Two samples (1 slice per sample) per treatment in each of two replicates were taken after inoculation, and 0 (after 24 h marination at 40°F (4°C), 4, 7 and 10 h during drying, and on days 15, 30 and 60 of storage at 77°F (25°C). Each sample was pummeled for 2 min with 25 ml of 0.1% sterile buffered peptone water (BPW) in a sterile sample bag. Serial decimal dilutions were made using 9-ml BPW tubes and 0.1 ml portions were surface plated onto tryptic soy agar with 0.1% sodium pyruvate (TSAP), and PALCAM agar. All plates were incubated at 86°F (30°C) for 48 h. The enumeration detection limit was –0.4 log CFU/cm^2. Enrichment of samples was done when countable colonies were not detected.

RESULTS

Figure 1 shows populations of *L. monocytogenes* during drying and storage of beef slices.

Effect of agar media

Bacterial populations recovered were higher on TSAP compared to PALCAM. These results suggest a level of bacterial injury as estimated by the differences in counts between nonselective (TSAP) and selective (PALCAM) agar media which may have been affected by acid adaptation, pre-drying treatment, and drying time. Although not expected in dried foods, injured cells may repair their damage and become a safety concern with product storage.

Effect of pre-drying treatments

Initial numbers of bacteria were significantly *(P£0.05)* reduced after 24 h-refrigerated marination in AATM (0.7-1.6 log) and TWTM (0.9-1.7 log), regardless of acid adaptation, and in MM when the product was inoculated with nonacid adapted culture compared to C (-0.2-0.8 log) and TM (0.1-0.7 log).

Effect of drying and storage

Regardless of acid-adaptation or the recovery media used, initial bacterial counts were significantly *(P£0.05)* reduced in all treatments after 4 h of drying. Bacterial populations further declined between 4, 7 and 10 h of drying, but these declines were not significant in all treatments. Results indicated that pre-drying treatments reduced bacterial populations during drying in the order TWTM (5.9-6.3 log CFU/cm^2) ≥AATM>MM>TM≥C (3.8-4.6 log CFU/cm^2). No significant difference *(P³0.05)* was found in inactivation of acid-adapted and nonadapted inocula within individual treatments. Bacterial populations continued to decline during storage in all treatments. In general, counts dropped below the detection limit in MM, AATM, and TWTM earlier than C and TM. Complete elimination of *L. monocytogenes* (enrichment negative) by 60 d occurred in MM, AATM, and TWTM, regardless of acid adaptation. and in TM when the products were inoculated with acid adapted culture (Figure 1).

IMPLICATIONS

These results indicated that acid-adaptation may not increase resistance of *L. monocytogenes* to microbial hurdles involved in jerky processing. In addition, use of pre-drying modified marinades may improve the effectiveness of drying in inactivating *L. monocytogenes*.

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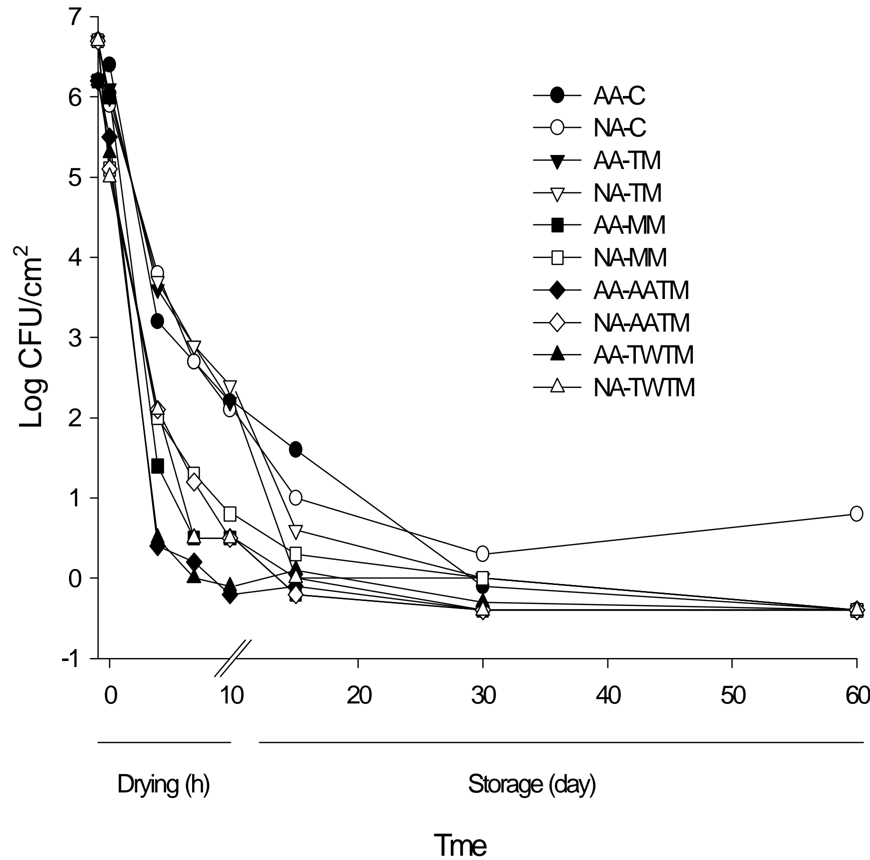

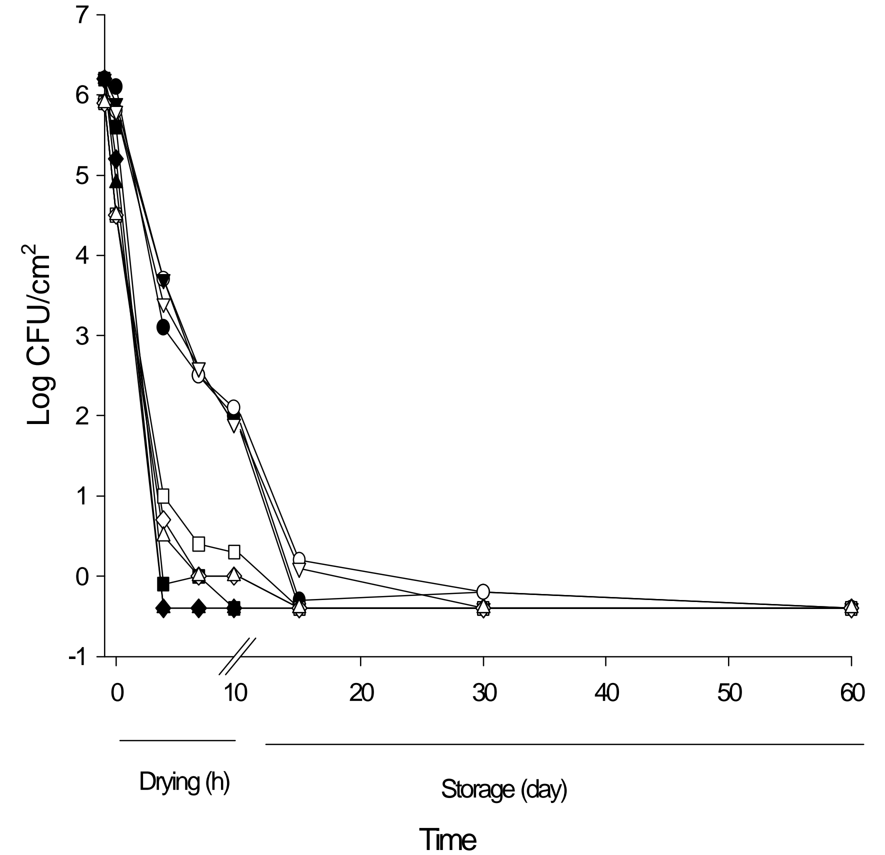

Figure 1. Survival of acid-adapted (AA) and nonadapted (NA) *Listeria monocytogenes* during drying (60°C, 10 h) and storage (25°C, 60 d) of beef jerky treated with control (C); traditional marinade (TM); modified TM [double amount, 1.2% sodium lactate, 5% EtOH, and 9% acetic acid (MM)]; acetic acid dip (5%) then TM (AATM); and Tween 20 dip (1%), then acetic acid dip (5%) followed by TM (TWTM). A, tryptic soy agar with 0.1% pyruvate (TSAP); B, PALCAM agar.