Effect of Acid Adaptation and Marinades on Destruction of *Escherichia coli* O157:H7 During Drying and Storage of Beef Jerky

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SUMMARY

Jerky is a marinated and dried meat product commonly produced by consumers using home-type dehydrators and eaten without further cooking. Pathogenic bacteria such as *Escherichia coli* O157:H7 may survive during the drying process and cause foodborne disease outbreaks. This study evaluated influence of various pre-drying marinades on destruction of acid-adapted or nonadapted *E. coli* O157:H7 on beef jerky during preparation, drying and storage. Dipping meat slices into 1% Tween 20 and/or 5% acetic acid prior to traditional marinade (TM), or using double amount of modified TM (added 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: *Escherichia coli* O157:H7, Jerky, Drying, Storage.

INTRODUCTION

The recent *Salmonella* and *Escherichia 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, in inactivating emerging pathogens (Harrison and Harrison, 1996; Faith et al., 1998). As a response to the problem, the USDA/FSIS has suggested cooking meat to 160°F (71.1°C) before drying to eliminate the risk of 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 be of reduced consumer acceptability. Use of chemical intervention strategies as pre-drying treatments, however, has not been studied adequately. Such interventions can be a viable option to avoid severe heat treatments and may provide residual antimicrobial effects during product storage. These chemicals may 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) in destroying acid-adapted or nonadapted *E. coli* O157:H7 cells during preparation, drying, and storage of whole muscle beef jerky.

MATERIALS AND METHODS

Preparation of Inoculum

A five-strain composite of *E. coli* O157:H7 was used for inoculating beef slices. These strains were EO139 (a venison jerky isolate), ATCC43895 (hamburger isolate), ATCC43890 (human isolate), ATCC43894 (human isolate), and ATCC43888 (human isolate). 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 95°F (35°C) prior to combining, centrifuging and diluting to a final level of 8.0 log CFU/ml.

Inoculation of Meat Slices

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 inoculated with 0.5 ml of the *E. coli* O157:H7 inoculum on the surface of each side at 15 min intervals for bacterial attachment. The resulting level of inoculum was approximately 6.5 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 2.0 pounds of meat: 60 ml soy sauce, 15 ml Worcestershire sauce, 0.6 g black, 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 2.0 pounds 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 of a 60% preparation, 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 treated with 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).

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 a 25 ml portion 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), sorbitol MacConkey agar (SMAC), and modified eosin methylene blue agar

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(MEMB). All plates were incubated at 95°F (35°C) for 48 h. The enumeration detection limit was –0.4 log CFU/cm^2. Enrichment of samples was done when necessary to detect uncountable potential survivors.

RESULTS

Figure 1 shows populations of *E. coli* 0157:H7 during drying and storage of beef slices.

Effect of Agar Media

Bacterial populations recovered were the highest on TSAP, followed by MEMB, and finally by SMAC. The results suggest a level of bacterial injury as estimated by the differences between nonselective (TSAP), semi-selective (MEMB), and selective (SMAC) agar media, which may be affected by acid adaptation, pre-drying treatment, and drying time.

Effect of Pre-drying Treatments

Initial bacterial numbers did not change (≤1.0 log CFU/cm^2) significantly *($P^3 0.05$)* after application of pre-drying treatments and holding of meat slices at 40°F (4°C) for 24 h before drying, regardless of acid adaptation, marination treatment or agar medium (Fig 1).

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 and 7 h of drying, but these declines were not significant in all treatments. No significant reduction in bacterial populations was found in any treatment inoculated with either acid-adapted or nonadapted cultures between 7 and 10 h of drying. Results indicated that pre-drying treatments reduced bacterial populations during drying in the order TWTM (4.9-6.7 log CFU/cm^2)>AATM>MM> C≥TM (2.8-4.9 log CFU/ cm^2). Populations of acid-adapted *E. coli* O157:H7 decreased faster *($P<0.05$)* in AATM and TWTM than nonadapted cells during drying while no significant difference was found in inactivation of acid-adapted and nonadapted inocula in C and TM. MM was more effective in inactivating the nonadapted than the adapted inoculum. 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 in all agar media, regardless of acid adaptation. Complete elimination of the pathogen (enrichment negative) by 60 d occurred in MM, AATM, and TWTM (Figure 1).

IMPLICATIONS

These results indicated that acid-adaptation of *E. coli* O157:H7 may not cause an increased resistance to the microbial hurdles involved in beef jerky processing and that use of food grade chemicals in jerky marination may improve the effectiveness of drying in inactivating *E. coli* O157:H7.

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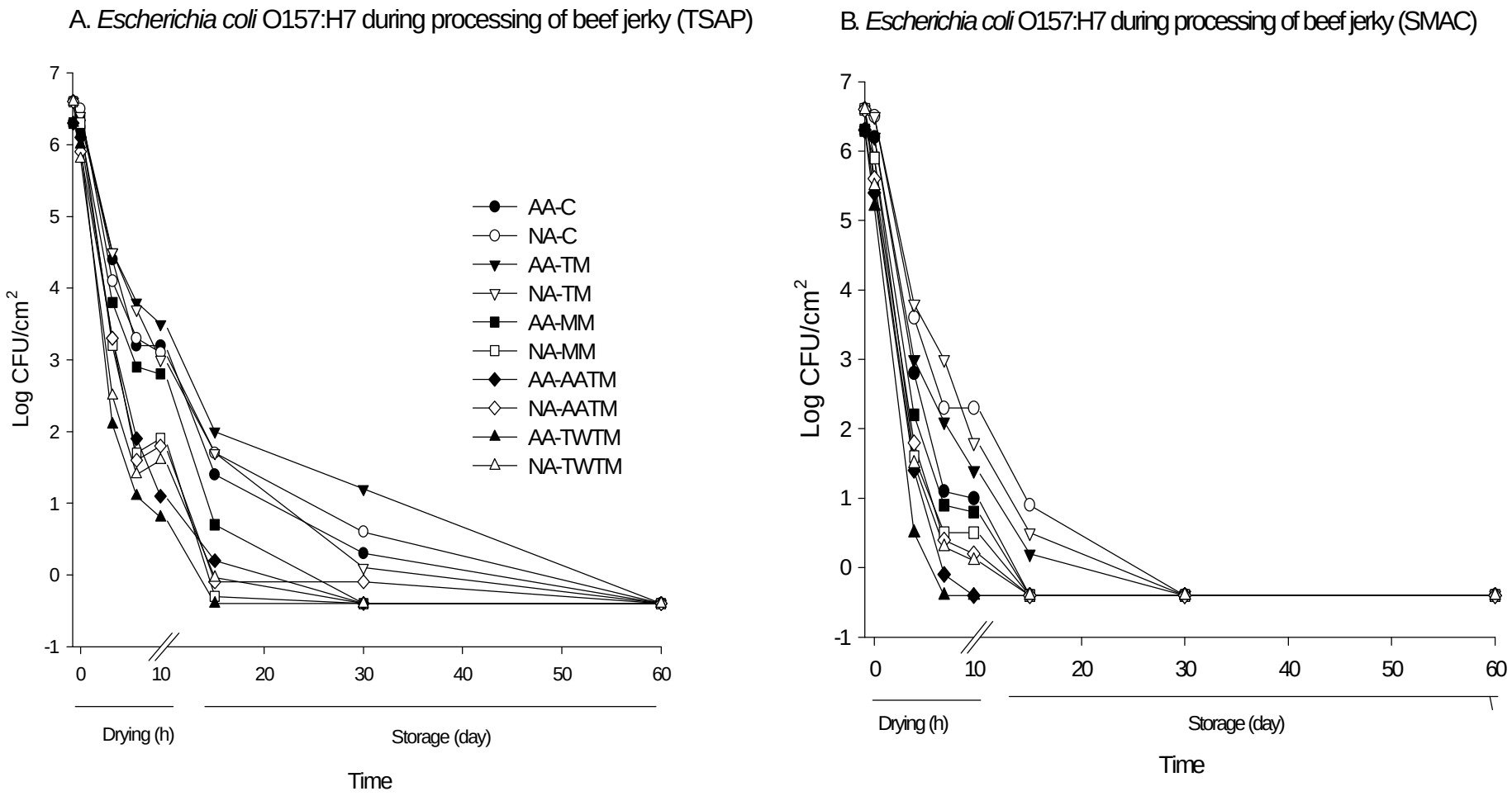

Figure 1. Survival of acid-adapted (AA) and unadapted (NA) *Escherichia coli* O157H7 during drying (60°C, 10 h) and storage (25°C, 60 d) of beef jerky treated with control (C); traditional marinade (TM); modified TM [double amount, 1.2% sodium lactate, 5% EtOH, and 9% acetic acid (MM)]; acetic acid dip (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, sorbitol Mac Conkey agar (SMAC).