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SURVIVAL OF *ESCHERICHIA COLI* O157:H7, *SALMONELLA* SPP. AND *LISTERIA MONOCYTOGENES* ON BEEF JERKY

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Introduction

Jerky is a common ready to eat product that can be purchased at just about any gas station, grocery store and small processing facility in the United States. Many small and very small plants manufacture jerky. It is important that these small and very small plants be able to validate that the product they manufacture is safe and free from pathogens. Many of the small processors use smokehouses with minimal controls, especially for humidity which are similar to home dehydrators. Faith et al. (1998) evaluated ground and formed jerky that had been dried using processes that were similar to home style dehydrators. They reported that viability of bacteria was reduced as the drying temperature increased and drying time increased. In the past, control of pathogens for jerky was due to reduced water activity. Control of most bacteria occurs at water activities below 0.90 (Jay, 1986). Calicioglu et al. (2003a) reported a 5 log reduction in *Escherichia coli* O157:H7 inoculated post-drying after 7 days of storage. The water activity of the jerky post-drying was between 0.564 and 0.696. Water activity below 0.85 has been used in other countries to establish safety of jerky (Agriculture and Agri-Food Canada, NZFSA). New guidelines from the USDA suggest lowering water activity to 0.80 to control *Salmonella* and *E. coli 0157:H7* along with processing with high humidity at the first of the manufacturing process.

Listeria monocytogenes has been a new problem that most small processors are now dealing with on ready to eat products. *Listeria* is normally a problem because of post processing contamination. Calicioglu et al. (2002) reported that *Listeria* numbers were reduced during the drying process and that the use of acid marinades helped increase this reduction. Työppönen et al (2003) observed that traditional processing procedures for dried, and fermented and dried sausages were not sufficient to prevent the survival of *Listeria monocytogenes* and *Escherichia coli O157:H7*. Therefore it is important to determine the effect of different water activities on the survivability of select pathogens. With the uncertainty of survival of different pathogens in dried products, it is important for processors to validate the process they are using to manufacture jerky that is being labeled shelf stable.

Objectives

The objective of this study was to determine the survivability of *E. coli* O157:H7, *Salmonella spp.* and *Listeria monocytogenes* on whole muscle jerky dried without humidity and stored in a vacuum package.

Methodology

Beef (*semimembranosus* muscle) was purchased from a small commercial facility for the manufacture of jerky. Meat was tempered at 4ºC for 24 h and sliced. A formulation containing beef (89.58% w/w), soy sauce (5% w/w), dextrose (2% w/w), salt (1.8% w/w), garlic powder (0.5% w/w), black pepper (0.5% w/w), onion powder (0.4% w/w), Cure #1 (0.18% w/w) and sodium erythorbate (0.04% w/w) was used to marinate the jerky. Each slice was inoculated by dipping in a cocktail of pathogens (Salmonella (4 strains *S. typhimurium* 04121V and 0363V, *S. abaetebua* 0817V and *S. choleraesuis* 0902V from Fisher Scientific, Denver, CO) , 3 x 10^6; *Listeria moncytogenes* (4 strains FSL J1-110, FSL C1-115, FSL J2-064, and FSL J2-054 from Martin Weidman, Cornell University) 6.25 x 10^7 and E. coli O157:H7 (one strain 0617V, Fisher Scientific, Denver, CO) 3.3 x 10^7). Three raw slices were tested to determine inoculation level. Jerky was placed on racks and dried in an ALKAR smokehouse (Alkar Smokehouses, Lodi WI) at 60°C with dampers open and fans running at maximum for the whole drying cycle. Samples were taken at 3, 6, 9, and 12 hours of drying to give three slices of jerky for each of five storage periods (0, 3, 6, 9, or 12 weeks). Each sample was tested for microorganism survival utilizing selective media. Internal temperature and water activity was also determined. Internal temperature was determined using hypodermic thermocouples (Omega Scientific, Tarzana, CA) inserted into 6 slices in each of three different full smokehouse loads. Water activity was determined with a Series 3 Decagon Aqualab water activity meter (Pullman, WA) on two different samples from each jerky slice at each drying and storage period. Three jerky slices from different places in the smokehouse were analyzed at each storage time for bacterial survival and water activity.

Ten grams of jerky slice per drying time were aseptically transferred into sterile plastic bags (Fisher Scientific, Denver). A 90-mL aliquot of 0.1% sterile peptone buffer (Difco) was added to each sample bag prior to pummeling with a stomacher for 2 min at room temperature. Serial decimal dilutions were made and pour-plated onto each of duplicate plates of each agar medium. Three different jerky slices per drying time were analyzed at each storage period. Bacteria were enumerated using tryptic soy agar (Difco) plus 0.1% sodium pyruvate (TSAP, total plate count), PALCAM agar (Difco) (*Listeria monocytogenes*), xylose-lysine-tergitol 4 agar (Difco) (XLT4, *Salmonella*), MacConkey sorbitol agar (Difco) (SMAC, *E. coli*) and modified eosin methylene blue agar (Difco) (MEMB, *E. coli*). PALCAM and half of the TSAP plates were incubated at 30ºC while the other plates were incubated at 35ºC. When numbers of the pathogen decreased to <10 cfu/g by direct plating, the presence/absence of the pathogen was determined by enrichment as described by Calicioglu et al. (2003a, b) for *Listeria* and *Salmonella*.

Data were analyzed using GLM of SAS. The absence of pathogens on selective agar was scored as 9 cfu for statistical analysis if there were no colonies on a plate. LSMEANS was used to separate means.

Results & Discussion

The internal temperature of jerky slices was similar to the smokehouse temperature after three hours of drying (Fig. 1). Calicioglu and co-workers (2003b) reported that the internal temperature of jerky slices were similar to the dehydrator

temperature after 6 hours of drying. The difference between these two reports is probably due to increased air flow and better temperature control in the smokehouse used in this study when compared to the home dehydrator used by Calicioglu et al. (2003b). The total number of colony forming units declined as drying time increased (Fig. 2). The total number of *E. coli, Salmonella* and *Listeria* also significantly declined as drying time increased. Drying of jerky resulted in a 2 log reduction of *Listeria* after 6 hours of drying which increased to a 3 log reduction after 12 hours. Drying of jerky slices inoculated with *E. coli* O157:H7 resulted in a 3 log reduction after 3 hours of drying and a 4 log reduction after 12 hours. After vacuum storage for three weeks there was no *Listeria* or *E. coli* recovered from the jerky strips. Furthermore after enrichment there was no *Listeria* or *E. coli* resuscitated. *Salmonella* however did survive storage up to 3 and 6 weeks of storage but was reduced to below detectable limit after 9 and 12 weeks of storage. *Salmonella* was recovered after enrichment, but in very low numbers (5 cfu). Water activity reduced as the drying time increased (Table 1) however at all drying times it was low for jerky products.

Table 1 Effect of drying and storage on the water activity of jerky

	Water activity	SEM
Drying Time (hrs)		
0	0.886	0.012
1	0.823	0.012
3	0.548	0.005
6	0.406	0.005
9	0.320	0.005
12	0.278	0.005
Storage (weeks)		
0	0.624	0.004
3	0.580	0.006
6	0.426	0.006
9	0.585	0.006
12	0.503	0.006

Conclusions

Drying procedures currently used by most small processors will reduce the number of pathogens on the jerky, however drying does not reduce the number enough to meet the 7 log reduction USDA uses as a kill step. Drying and storing in a vacuum package does result in reduction of pathogens to below the detectable limit. The cause of the reduction of pathogens in storage is not clear. Some will be due to the lowered water activity but some may be due to pathogens being injured during drying and not being able to adapt to the vacuum packaged atmosphere.

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Figure 1 Internal temperature of jerky slices during drying at 60ºC.

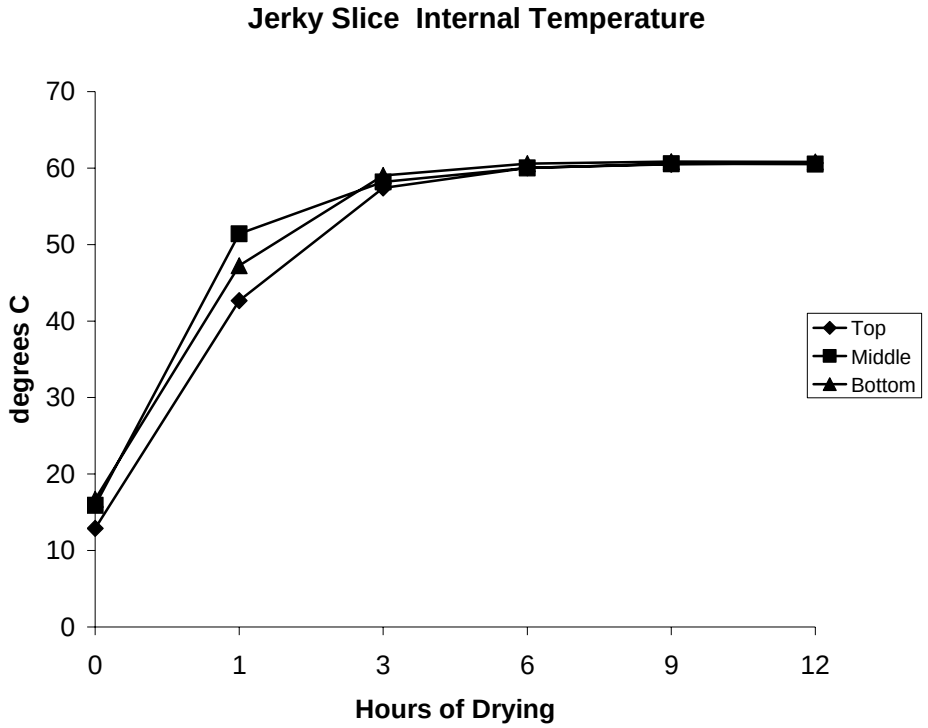


Figure 2. Effect of drying at 60ºC on the survival of *E. coli* O157:H7, *Salmonella spp*. and *Listeria monocytogenes*.

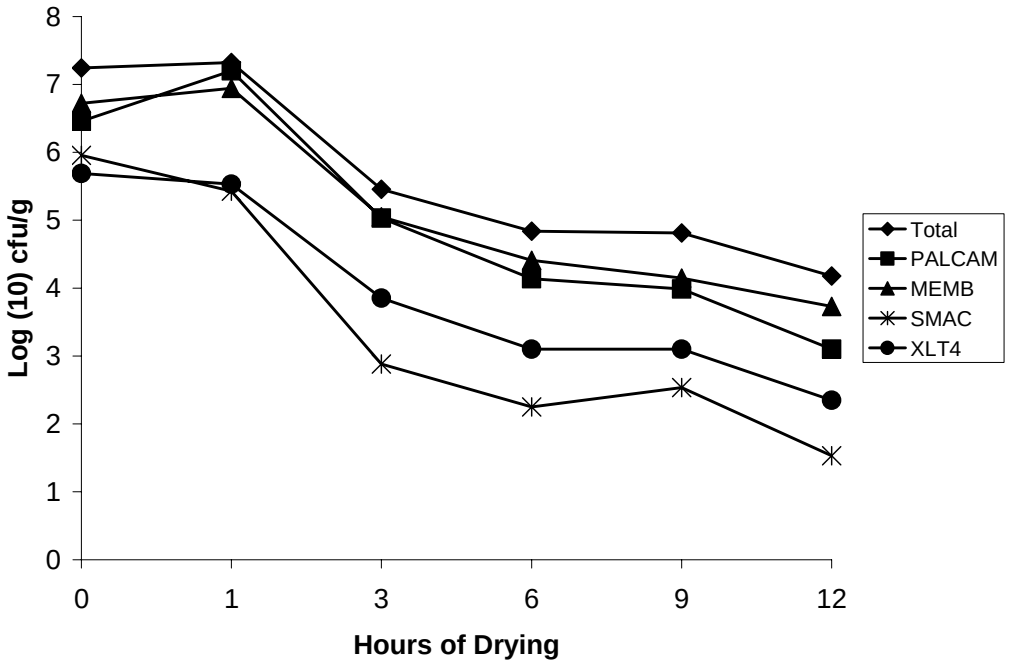
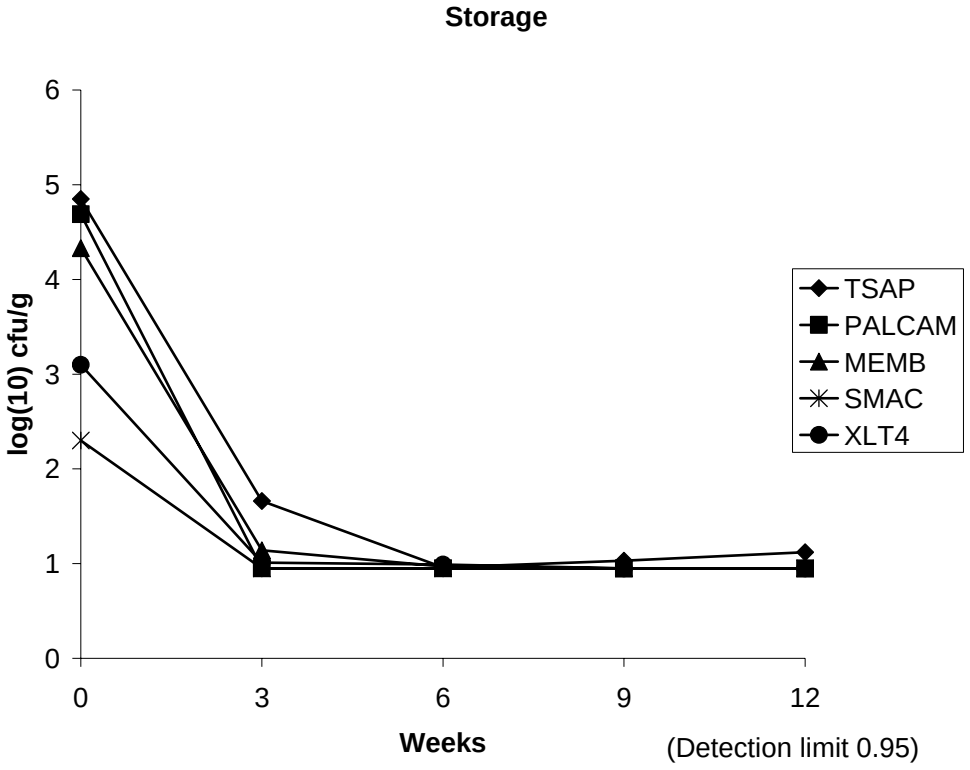


Figure 3. Effect of storage on the survival of *E. coli* O157:H7, *Salmonella spp*. and *Listeria monocytogenes*.


Storage
6
5
4
3
2
1
0
log(10) cfu/g
0
3
6
9
12
Weeks
TSAP
PALCAM
MEMB
SMAC
XLT4
(Detection limit 0.95)