Effect of Salt Reduction on the Quality and Shelf Life Characteristics of Deli-Style Roast Beef

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Summary with Implications

Concerns with excessive sodium intake have led to increased pressure on meat processors to reduce added salt in meat products. Quality characteristics and microbial growth were evaluated on deli-style roast beef slices formulated to contain varying concentrations of added salt. Salt concentration had no effect on microbial community composition, however increasing salt slowed microbial growth over time. Increasing salt increased cooking yield and decreased water activity. Salt reduction negatively impacts the texture, yield, and shelf life of deli-style roast beef, however salt concentrations within this range do not significantly alter spoilage flora community composition.

Introduction

Excess sodium intake has been a health concern for many years, however renewed efforts to reduce sodium in the diet have emerged recently. Much of the sodium in processed meat products is from added salt, therefore to achieve sufficient sodium reduction, added salt must be reduced. Yet, salt is essential to produce processed meats. The multi-functional properties of salt have been well documented and are necessary to provide the texture, flavor, bind, water holding capacity, and extended shelf life of processed meat. Salt can also alter the microbial composition of meat products, potentially shifting the spoilage flora toward slower growing, less detrimental groups of bacteria. Processed meats are essential in adding value to lower quality or less marketable cuts of beef, and sodium reduction is a major step in reducing the negative health stigma sometimes associated with processed meats. The objectives of this study were to determine the effects of salt reduction on the quality, textural, and shelf life properties of deli-style roast beef, and identify changes in the microbial community caused by varying salt concentrations.

Procedure

Ground and formed deli-style roast beef was produced at the UNL Loeffel Meat Laboratory using four different salt concentrations, 1.0%, 1.5%, 2.0%, and 2.5%, calculated on a meat block basis. For each treatment, a brine for 25% extension was formulated to contain the appropriate salt concentration plus 1.0% sugar and 0.35% sodium phosphates (on a meat block basis) and added water. Brine was mixed and added to 20 lbs. of ½" ground beef top round, and vacuum tumbled for 90 min. Tumbled meat was stuffed into 3.5" diameter pre-stuck fibrous casings using a vacuum stuffer, pressed, clipped, weighed, and hung on a smokehouse truck. Roast beef rolls were cooked to 160° F, chilled overnight at 35° F, and sliced the following day. Slices were vacuum packaged and stored in a covered opaque plastic container under refrigeration at 35° F for shelf life analyses. Water activity, cooking yield, and final salt concentration were analyzed on the day of slicing. The following were measured every two weeks starting on the day of slicing for 18 w of shelf life: Hardness, cohesiveness, springiness, and chewiness using texture profile analysis (TPA), pH, aerobic plate count (APC), anaerobic plate count (AnPC), and objective color (CIE L*, a*, b*). Change in color (ΔE) during storage was calculated using objective color values. For 14 w of storage time, bacterial communities were analyzed by sequencing of 16S rRNA using the Illumina MiSeq platform. Data were analyzed for interactions and main effects of salt concentration as a continuous variable, and storage time as a repeated measure, using the PROC GLIMMIX procedure of SAS. Statistical significance was determined at $P \leq 0.05$.

Results

Salt has a bacteriostatic effect in meat products, and some greater concentrations will slow or even halt bacterial growth. There was a storage time by salt concentration interaction for APC in samples ($P = 0.016$; figure 1). Aerobic bacterial growth for all treatments increased until week 8, where growth reached a plateau. At weeks 0 and 2, there was a positive linear response, where growth was increased as salt increased. From weeks 6 to 18, there was a negative response where increasing salt concentration reduced aerobic bacterial growth. Similarly, there was a storage time by salt concentration interaction for AnPC ($P = 0.020$). Anaerobic bacterial growth generally increased until around week 8 for all treatments. On weeks 4, 10, 12, 14, and 16 there was a negative linear response to salt concentration where anaerobic bacterial growth decreased as salt increased. On the remaining weeks, there was no significant salt concentration response.

The majority of vegetative cells are destroyed during the cooking process, therefore most bacteria present on the finished product is introduced during slicing or packaging. Furthermore, growth throughout storage time may be altered by packaging, ingredients, storage temperature and many other intrinsic or extrinsic factors. In the current study, family *Pseudomonadaceae* was dominant throughout storage time, regardless of salt concentration. Figure 2 shows the relative abundances of various microbial families based on salt concentration and storage time. There were no changes in the microbial flora due to salt concentration; pseudomonads dominated spoilage regardless of treatment. At week 0, *Pseudomonadaceae* relative abundance was 58.9%, increased at week 2, and remained between 84% and 99.7% of all bacteria for the remainder of storage time. The current results indicate that salt concentrations

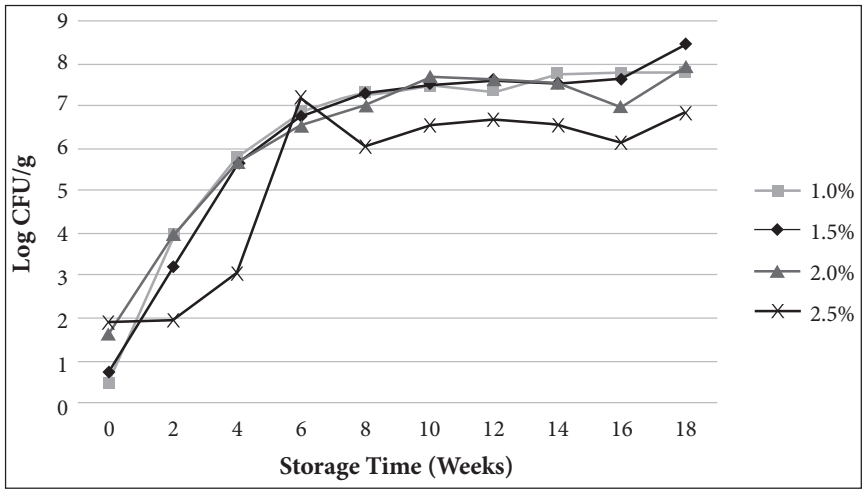

Figure 1. Interaction of salt concentration (%) and storage time on aerobic plate count in deli-style roast beef

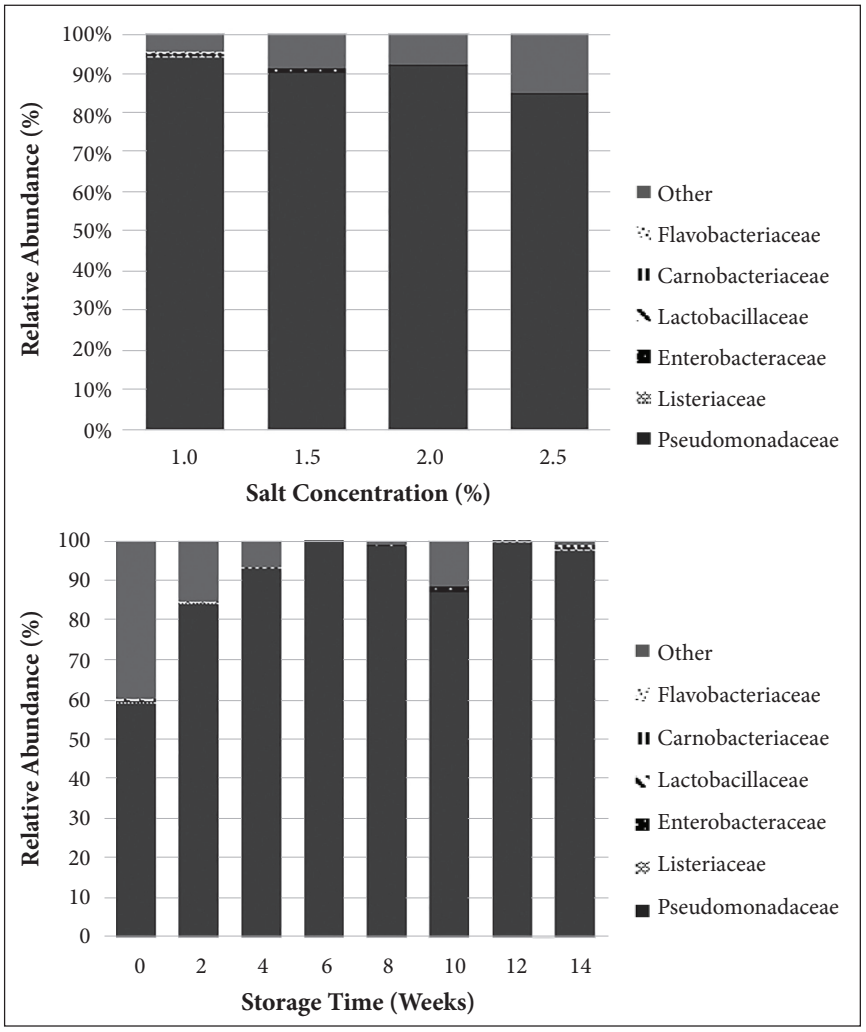

Figure 2. Relative abundances of bacterial families as affected by salt concentration and storage time in deli-style roast beef slices

within this range do not affect microbial community composition, but rather the makeup up of the initial load may have the most impact.

In processed meats, salt is responsible for protein extraction, which alters product bind and texture. Texture profile analysis (TPA) was used to instrumentally determine the texture differences caused by increasing salt concentration. Hardness showed a quadratic response to salt concentration ($P < 0.001$) where hardness decreased from 1.0% to 1.5% and 1.5% to 2.0% salt, but decreased less rapidly from 2.0% to 2.5%. Cohesiveness and springiness both displayed a linear response ($P < 0.001$ and $P = 0.002$, respectively) where cohesiveness decreased and springiness increased as salt concentration increased. Chewiness had a quadratic response, which increased greatly from 1.0% to 1.5% and 1.5% to 2.0% salt, and increased less rapidly from 2.0% to 2.5%.

Salt concentration affected objective color, having a cubic response for L* (lightness; $P = 0.034$), a quadratic response for b* (yellowness; $P < 0.001$), and a linear response for a* (redness; $P < 0.001$). Samples decreased in lightness from 1.0% to 2.0% salt, and then increased in lightness from 2.0% to 2.5%. Yellowness decreased from 1.0% to 2.0%, and increased from 2.0 to 2.5%. As salt concentration increased, redness decreased. Salt concentration did not affect ΔE (overall color change during storage time).

Throughout storage time, the growth of lactic acid bacteria results in lactic acid production, reducing meat pH. Sample pH was affected by storage time, where pH increased from week 0 to week 6, and then decreased from week 6 for the remainder of storage time. There was a cubic response on pH from salt concentration, where pH decreased from 1.0% to 1.5%, increased from 1.5% to 2.0%, and decreased again from 2.0% to 2.5%. Cooking yield displayed a cubic response ($P < 0.001$), where yield increased greatly from 1.0% to 1.5% salt, but increased at a diminishing rate from 1.5% to 2.0%, and 2.0% to 2.5%. Both water activity and measured salt concentration in the finished product showed a linear response ($P < 0.001$), where water activity decreased as salt increased, and measured salt in the finished product increased as ingoing salt concentration increased.

Table 1. Main effects of salt concentration on various quality and microbiological measurements of deli-style roast beef slices.

	Salt Concentration					P Value		
	1.0%	1.5%	2.0%	2.5%	SE	Linear	Quadratic	Cubic
Cooking Yield (%)	72.79	84.43	87.16	90.60	0.67	<0.001	<0.001	0.014
Water Activity	0.986	0.983	0.983	0.980	0.001	<0.001	0.487	0.099
Measured Salt (%)	0.78	1.06	1.36	1.68	0.04	<0.001	0.625	0.987
pH	6.06	6.00	6.05	6.03	0.03	0.715	0.288	0.026
L*	60.02	59.40	58.18	58.57	0.36	<0.001	0.031	0.034
a*	8.61	8.34	8.12	8.03	0.12	<0.001	0.277	0.836
b*	9.42	8.78	8.43	8.64	0.16	<0.001	<0.001	0.558
Color Change (ΔE)	1.76	1.43	1.54	1.41	0.24	0.185	0.524	0.339
Hardness	1917.0	1664.9	1483.1	1424.0	47.5	<0.001	0.007	0.161
Cohesiveness	0.313	0.308	0.293	0.288	0.007	0.012	0.458	0.074
Springiness	0.355	0.356	0.380	0.391	0.017	<0.001	<0.001	0.678
Chewiness	213.17	182.43	164.73	160.36	13.07	<0.001	0.970	0.211
APC (log CFU/g) [1]	6.26	6.22	6.25	5.29	0.27	—	—	—
AnPC (log CFU/g)[1]	2.77	1.41	1.90	1.12	0.61	—	—	—

[1]Indicates a significant salt concentration by storage time interaction ($P \leq 0.05$) for aerobic plate count (APC) and anaerobic plate count (AnPC), therefore main effect P values are not reported.

Conclusions

Results of this study indicate that besides reducing total bacterial growth, salt concentration between 1.0% and 2.5% has a minimal effect on microbial community composition. Furthermore, although *Pseudomonadaceae* growth is typically suppressed in cooked, vacuum packaged products, a significant initial load of pseudomonads may cause them to dominate microbial populations. Decreasing salt concentration resulted in poorer textural properties of roast beef likely related to reduced protein solubilization and cross-linking during processing and cooking. Increasing salt concentration resulted in increased cooking yield through improved moisture retention during cooking process. The negative effects of salt reduction were amplified as salt concentration was reduced. Although salt concentration had a statistically significant effect on instrumental color, differences in color values in this study are likely of little practical value. Microbial community dynamics of cooked deli meats should be further explored, especially with regard to antimicrobials or other ingredients that may have a more profound effect on microbial communities, as well as any changes in product quality caused by such ingredients.

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