The Effect of pH and Nitrite Concentration from Celery Juice Concentrate in Ham Slices on the Antimicrobial Impact and Ham Quality Effects of Celery Juice Concentrate Compared with Conventional Sodium Nitrite

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Summary and Implications

The impact of pH and nitrite from celery juice concentrate (CJ) on the growth of *L. monocytogenes* on ham slices, and quality attributes of the ham were evaluated. The pH of the ham was increased by addition of CJ. The CJ treatments at both 100 and 200 mg/kg of nitrite resulted in growth of *L. monocytogenes* ($p>0.05$) similar to that of conventional nitrite at the same concentrations. Reducing the pH of CJ before addition to the ham had greater impact on *L. monocytogenes* growth at 200 mg/kg nitrite than at 100 mg/kg. Consequently, celery juice concentrate can increase meat product pH which has implications for the antimicrobial impact of nitrite in some products.

Introduction

Celery juice concentrate is prominently used by the meat industry for natural and organic cured meats because nitrite per se is not allowed. Typically, celery concentrate has a pH ranging from 8.5-10 as provided by suppliers and may impact meat product pH as a result. It is important to note that nitrite's effectiveness as an antimicrobial for many pathogens relies heavily on pH. Restructured hams were utilized to assess our hypothesis that the elevated pH of celery concentrate would decrease the antimicrobial impact of nitrite. In addition, the celery concentrate was compared to conventional nitrite using the same nitrite concentrations and the same pH to determine whether the various components present in the celery concentrate (proteins, carbohydrates, minerals, etc.) might affect the impact of nitrite on *L. monocytogenes*, independent of pH.

Materials and Methods

Seven ham treatments (control with no nitrite, 100 mg/kg added nitrite from celery juice both pH adjusted and unadjusted, 200 mg/kg added nitrite from celery juice both pH adjusted and unadjusted, 100 mg/kg conventional nitrite, 200 mg/kg conventional nitrite) were produced at the Iowa State University Meat Laboratory. Pre-converted celery juice concentrate (VegStable 504, Florida Food Products, Eustis, FL) containing 15,000 ppm of nitrite was used as the natural source of nitrite. For the pH adjusted hams, the celery juice concentrate was first dissolved in distilled water, a 10% solution of citric acid added to celery juice to lower the celery juice pH to the target pH of 6, then added to the ham mixture to achieve the targeted pH and sodium nitrite concentration in the hams. After cooking and chilling, each ham treatment was sliced into 11 mm thick portions weighing approximately 25 g $\pm$ 0.5 g. For microbiology analysis, single slices were placed in separate bags and vacuumed packaged. For chemical analysis, two 25 gram slices were placed together into one bag and vacuum packaged.

Five strains of *Listeria monocytogenes* (Scott A, H7969, H7764, H7769, H7762) were utilized for this study, and combined to create a 50 ml cocktail (~10^9 cells per ml) to obtain a target inoculation of 10^4 cells per gram of the ham slices. On days 0, 3, 7, 10, 14, 21, 28, and 35 following inoculation, one inoculated 25 g sample from each treatment was aseptically removed from its packaging and surface-plated in duplicate, incubated at 35°C for 48 hours, and counted.

Statistical analysis was conducted using a randomized complete block design including replication, treatment, day and treatment x day in the model as fixed block effects. Measurements were analyzed using the statement proc glimmix with the Statistical Analysis System.

Results and Discussion

Figure 1 shows the *L. monocytogenes* growth on ham slices for all treatments. Significant differences ($p > 0.05$) amongst treatments were not detected until day 7. As expected, the control (no nitrite source) had significantly ($p < 0.05$) greater numbers of *L. monocytogenes* than all other treatments for days 10-35. On days 21-35, the adjusted 200 mg/kg CJ treatment (treatment 5) had significantly ($p < 0.05$) lower *L. monocytogenes* growth than the 200 mg/kg CJ treatment (treatment 4). The pH differences ($p < 0.05$) were significant for the duration of the experiment between the 200 mg/kg CJ treatment (treatment 4) and adjusted 200 mg/kg CJ treatment (treatment 5) where the adjusted 200 mg/kg CJ treatment maintained a lower pH by about 0.3 pH units. Since the concentration of nitrite for both of these treatments was the same, the pH difference may have affected the microbial growth differences observed at 200 mg/kg in this experiment. Considering that the adjusted and

unadjusted 100 mg/kg celery concentrate treatments resulted in no differences in *L. monocytogenes* growth, the difference between the unadjusted and adjusted 200 mg/kg celery juice treatments suggests that the pH may be more important at greater concentration of nitrite for affecting the subsequent *L. monocytogenes* growth as observed in this experiment. On all days except day 14, all 100 mg/kg nitrite treatments (100 mg/kg CJ, adjusted 100 mg/kg CJ, and 100 mg/kg conventional sodium nitrite) were statistically similar ($p > 0.05$). Ultimately, these treatments at the end of the experiment, reached the same population, which suggests that, at 100 mg/kg nitrite, celery concentrate is just as effective as sodium nitrite in reducing *L. monocytogenes* growth when used at that concentration. In addition, the adjusted 200 mg/kg celery concentrate treatment (treatment 5) in this study was not different ($p > 0.05$) from the 200 mg/kg conventional sodium nitrite (treatment 7) for suppression of *L. monocytogenes* growth on all days except day 28 ($p < 0.05$). Because the 200 mg/kg CJ treatment (treatment 4) was different ($p < 0.05$) than the adjusted 200 mg/kg CJ treatment (treatment 5), the results suggest that the pH adjustment in treatment 5 (adjusted 200 ppm CJ) affected the antimicrobial impact of the celery concentrate. The adjusted 200 mg/kg CJ treatment (treatment 5) also suppressed growth ($p < 0.05$) more effectively than all other treatments except treatment 7 (200 mg/kg conventional sodium nitrite) on days 21 and 35. The results from this experiment suggest that at higher concentrations of celery concentrate, the pH effect of celery juice on the antimicrobial impact of nitrite is more prominent, probably due to the pH effect on nitrite reactions at a greater nitrite concentration. It is likely that more nitrite in the celery concentrate when combined with reduced pH increased the antimicrobial impact of the nitrite.

While this study suggests that celery concentrate was as effective as conventional nitrite in ham at equal nitrite concentrations, the potential pH impact of the celery concentrate, which was 9.2, is likely to be of significance for nitrite reactions in some product applications.

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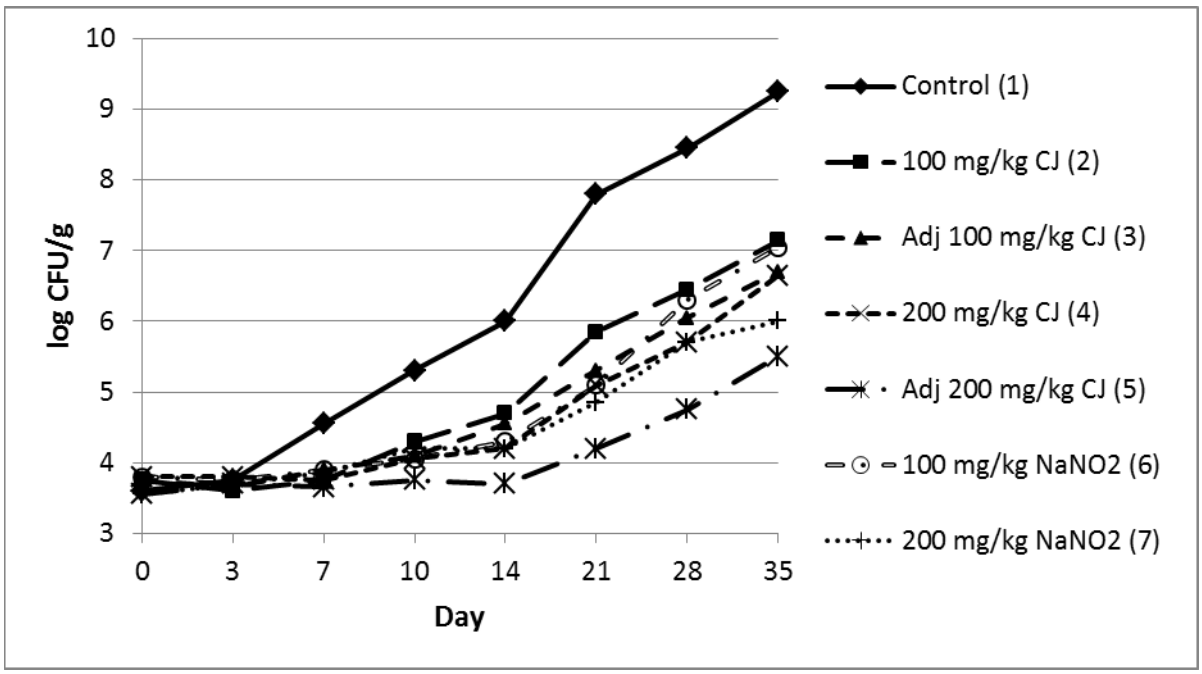

Figure 1. Least square means of *L. monocytogenes* (log CFU/g) growth amongst ham treatments after 10^4 log CFU/g inoculation held at 4˚C for 35 days.