Sodium Lactate Affects Sensory and Objective Characteristics of Tray-Packed Broiler Chicken Breast Meat

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ABSTRACT The objective of this study was to determine the antimicrobial properties of sodium lactate solutions adjusted to various pH values. The effectiveness of sodium lactate increases with increased concentrations; however, there are off-flavor development problems associated with increasing concentrations of sodium lactate above 2.0%. This study evaluated the effects of 2% sodium lactate treatments, adjusted to various pH values, on sensory characteristics, instrumental texture, and microbial populations of tray-packed broiler breast meat. Breast meat was treated with either tap water (pH 7.85) or 2% sodium lactate solutions (pH 7.30, 5.50, 5.00, 4.50, and 4.00) and stored at 2 ± 1°C for 12 d. Approximately 15% of the panelists reported acidic aftertastes in samples treated with pH 5.00 sodium lactate solutions, and 10% of the panelists reported slight sodium or metallic off-flavor in all samples treated with sodium lactate. Instrumental texture measurements were similar (P > 0.05) for all treatments. Sodium lactate (pH 7.30 and 5.50) enhanced (P < 0.05) cooking yields and retarded the growth of spoilage bacteria (pH 5.50 and 5.00). Due to the development of severe discoloration and intense acidic off-odors and -flavors, testing was not conducted on samples treated with pH 4.50 and 4.00 sodium lactate solutions.

(Key words: shelf life, chicken breast meat, microbiology, sodium lactate)

INTRODUCTION

Sodium lactate has been used extensively in various food systems primarily for its antimicrobial properties (Papadopoulos et al., 1991; Zeitoun and Debevere, 1991; Williams et al., 1995). Researchers have reported antitoxin properties of sodium lactate in poultry and seafood systems, when employed at concentrations of 1 to 7% (Anders, et al., 1987; Maas et al., 1989). In general, the effectiveness of sodium lactate increases with increased concentrations. However, there are sensory problems associated with increasing concentrations of sodium lactate above 2.0%. Papadopoulos et al. (1991) reported that cooked vacuum-packed beef rounds containing 3 and 4% sodium lactate resulted in higher cooking yields, enhanced color, and increased shelf life. However, panelists reported mild throat irritations and sodium aftertastes in the roasts treated with 4% sodium lactate. The aftertaste was even more pronounced in fresh catfish fillets. Although the shelf life of fresh unseasoned, Ictalurus nebulosus, marmoratus catfish fillets was extended after treatment with 3% sodium lactate, the fillets were unacceptable for consumption because of an objectionable sodium metallic aftertaste (Williams et al., 1995). The sodium aftertaste was due largely to the 12 to 12.5% sodium content of sodium lactate. It was determined that treating catfish fillets with 2% sodium lactate solutions, adjusted to pH 5.50, resulted in an acceptable product with extended shelf life of an additional 3 d (Williams et al., 1995). Adjusting the pH of sodium lactate also has the advantages of limiting the concentration of sodium added to the breast meat or other poultry products and reducing the usage level of sodium lactate. Williams (1993) determined that treating fresh catfish fillets with 2% sodium lactate (based on total batch weight) adjusted to pH 5.50 was more effective in reducing aerobic plate counts than 3% sodium lactate (based on total batch weight). The objective of this study was to determine the effects of 2% sodium lactate treatments, adjusted to various pH values, on sensory characteristics, instrumental texture, and microbial populations of tray-packed chicken broiler breast meat.

Abbreviation Key: APC = aerobic plate count; NaL = sodium lactate.
MATERIALS AND METHODS

Sample Preparation

Fresh boneless and skinless chicken breasts were purchased from a local supermarket approximately 72 h after processing. The breasts were split into halves, divided into four groups, and treated with either tap water (control, pH 7.85), or 2% sodium lactate solutions with pH values of 7.30 (original pH of sodium lactate, NaL-7.30), 5.50 (NaL-5.50), 5.00 (NaL-5.00), 4.50 (NaL-4.50), and 4.00 (NaL-4.00). No spices, flavorings, or flavor potentiators were used in this study. The pH of the treatment solutions was adjusted using 88% lactic acid solutions.3 The sodium lactate solution (60% sodium lactate solution)3 in each treatment represented 2% of the total product weight. The chicken breasts were combined with the appropriate sodium lactate treatment solution, vacuum tumbled4 (15 min at approximately 172.32 kPa), placed into styrofoam trays,5 over-wrapped with polyvinyl chloride film (64 gauge film, oxygen transmission rate: 1,400 cc/m2 per 24 h at 22.8 °C, water vapor transmission rate: 32 g/24 h at 37.8 °C, Catalog No. RMF 61HY),6 heat-sealed, and stored at 2 ± 1 °C for 12 d. Samples were analyzed in triplicate after 0, 3, 7, and 10 d for determination of microbial growth.

Sensory Evaluation and Cooking Yield

The sensory evaluation was approved by the University of Florida’s Review Board for Human Research. Cooking and dissecting of the cooked muscles were conducted as described by Lyon and Lyon (1991). Six boneless and skinless whole chicken breasts were rinsed under running tap water to remove any bone, or other minute residuals, drained for approximately 1 min, and weighed. Copper-constantan thermocouples7 were inserted into the thickest part of the muscles prior to cooking. The breasts were wrapped in aluminum foil, placed in roasting pans (six breast halves per pan per treatment), and cooked at 176.7 °C, in a conventional preheated gas oven, to 80 °C internal muscle temperature. The cooked chicken was allowed to cool at room temperature for 10 min, weighed, and separated into Pectoralis major and Pectoralis minor. A 1.9-cm-wide strip of muscle, originating at the humeral insertion and terminating at the anterior end of the keel, so that muscle fibers were parallel, was cut from the medial area of each P. major muscle and reserved for instrumental texture analyses. The remaining P. major muscles from each treatment were cubed (approximately 1.25 cm × 1.2 cm × thickness of cooked cut) and served (two cubes per treatment) along with room temperature water and unsalted crackers (two crackers per panelist) to an 11-member trained panel. Samples were served approximately 10 min after cooled to room temperature. A total of four sessions (i.e., Days 0, 3, 7, and 10) were conducted per replication. Each treatment was assigned a one-digit numerical code, and order of presentation to the panelists was randomized. Four samples (i.e., one sample from each treatment) were presented to each panelist. Panelists were instructed to eat crackers, drink water between each sample to clear their palate, and pause for 20 s between samples. Empty cups were provided for expectoration of the samples.

Panelists included faculty, staff, and students at University of Florida. Prior to testing, panelists received approximately 24 h of training over a 5-d period. During the training sessions, panelists were presented samples exhibiting desired and undesired chicken flavor, overall tenderness, and off-flavor characteristics. Panelists were served chicken samples containing each of the off-flavors of concern, which included rancid, soapy, sour, bitter, metallic, sodium, and acid. They were also asked to document any objectionable texture and off-odor characteristics detected. Sensory evaluations were performed in a 12-booth partitioned sensory room, equipped with exhaust fans, and illuminated by a combination of red and white lighting. Each of the 12 booths was equipped with a ceiling lighting system to provide red, white, blue, or yellow lighting as needed. Eight-point hedonic scoring scales were employed for chicken flavor intensity, and overall tenderness (8 = extremely intense/tender, 7 = very intense/tender, 6 = moderately intense/tender, 5 = slightly intense/tender, 4 = slightly bland/tough, 3 = moderately bland/tough, 2 = very bland/tough, and 1 = extremely bland/tough). A six-point scale was employed for off-flavor (6 = none detected, 5 = threshold, barely detected, 4 = slight off flavor, 3 = moderate off-flavor, 2 = strong off-flavor, 1 = extreme off-flavor).

Instrumental Texture Measurements

Texture measurements were conducted as described by Lyon and Lyon (1991). Two 1.9-cm-wide strips were each oriented in the Warner-Bratzler Shear attachment (type D.D., catalog no. 2830-002)8 to the Model 1011 Instron.8 Cross head speed was 200 mm/min with a 50-kg load cell, and full scale range of 10 kg. Shearing force was perpendicular to the direction of the fibers, and force to shear the sample was recorded in kilograms. Three breasts (total of six 1.9-cm-wide strips) were evaluated for texture per treatment per replication.

Microbiological Analysis

Each 25-g sample was placed into a Nasco Whirl-Pak® stomacher bag along with 225 mL of sterile 0.1% peptone
TABLE 1. Sensory evaluation of chicken breast meat treated with sodium lactate (NaL) at different pH values and stored at 2 ± 1 C for 10 d

<table>
<thead>
<tr>
<th>Parameter1</th>
<th>Treatment</th>
<th>0 d</th>
<th>3 d</th>
<th>7 d</th>
<th>10 d</th>
</tr>
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<td>Chicken flavor intensity</td>
<td>Control</td>
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<td>5.24</td>
<td>4.82</td>
<td>5.10</td>
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<td></td>
<td>NaL-7.30</td>
<td>5.07&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>5.24</td>
<td>5.15</td>
<td>4.95</td>
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<tr>
<td></td>
<td>NaL-5.50</td>
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<td>5.03</td>
<td>5.15</td>
<td>5.00</td>
</tr>
<tr>
<td></td>
<td>NaL-5.00</td>
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<td>5.11</td>
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<td>0.13</td>
<td>0.13</td>
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<tr>
<td>Overall tenderness</td>
<td>Control</td>
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<td>7.03</td>
<td>6.89</td>
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<tr>
<td>Off-flavor</td>
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<td>5.50&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.85</td>
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</table>

<sup>a,b</sup>Means within a column and parameter with no common superscript differ significantly (P < 0.05); n = 33 values per mean.

<sup>1</sup>Scoring scale: chicken flavor intensity (6 = moderately intense, 5 = slightly intense, 4 = slightly bland, 3 = moderately bland, 2 = very bland, and 1 = extremely bland); overall tenderness (7 = very tender, 6 = moderately tender, 5 = slightly tender, 4 = slightly tough, 3 = moderately tough, 2 = very tough, and 1 = extremely tough); off-flavor (6 = none detected, 5 = threshold, 4 = slight off-flavor, 3 = moderate off-flavor, 2 = strong off-flavor, and 1 = extreme off-flavor).

Sodium lactate in chicken breast meat has been studied to evaluate its effect on sensory attributes and microbiological safety. The experiments were conducted with different pH values and stored at 2 ± 1 C for 10 days. The sensory evaluation included chicken flavor intensity, overall tenderness, and off-flavor. The data were analyzed using analysis of variance (ANOVA) and the General Linear Models procedure of SAS® software, and the LSMEANS procedure for generating standard errors of the mean (SAS Institute, 1990; Littell et al., 1991). Interaction between treatments, storage, and replications was tested for significance (P < 0.05). Significant differences among treatments and storage means were determined using Duncan’s multiple range test (SAS Institute, 1990).

RESULTS AND DISCUSSION

**Sensory Evaluation and Cooking Yields**

Due to the development of severe discoloration and intense acidic off-odors and -flavors, testing was not conducted on samples treated with NaL-4.50 and NaL-4.00. Except for Day 0, panelists scored all treatments similarly (P > 0.05) for chicken flavor intensity, and overall tenderness through 10 d (Table 1). The degree of off-flavor detected in all sodium lactate treated breast meat was significantly (P < 0.05) more intense than that of the control through 3 d. After 7 and 10 d, all treatments had developed a slight off-flavor. Approximately 15% of the panelists reported acidic aftertastes in samples treated with NaL-5.00 solutions; and approximately 10% reported a slight sodium or metallic off-flavor in all samples treated with sodium lactate. The slight acidic aftertaste reported for the NaL-5.00 treated breast meat may account for its significant decline in chicken flavor intensity on Day 0. All sensory analyses were discontinued after 10 d because of the development of an objectionable off-odor and off-flavor in the control breast meat.

**pH**

Each 11-g sample was combined with 99 mL of deionized water, and blended in a Waring blender for 1 min. The sample homogenate was measured for pH. Triplicate samples were measured per treatment per replication.

**Data Analysis**

All experiments were replicated three times. The experimental design was a randomized complete block design with four treatments. Data of the three replications were pooled and analyzed using analysis of variance of the General Linear Models procedure of SAS® software, and the LSMEANS procedure for generating standard errors of the mean (SAS Institute, 1990; Littell et al., 1991). Interaction between treatments, storage, and replications was tested for significance (P < 0.05). Significant differences among treatments and storage means were determined using Duncan’s multiple range test (SAS Institute, 1990).
Cooking yields decreased as storage time increased (Table 2). Treating breast meat with NaL-7.30 and NaL-5.50 resulted in significantly higher ($P < 0.05$) cooking yields after 3 and 7 d storage, when compared to the control breast meat. The lower cooking yields reported for NaL-5.00 might be largely attributed to a slight to moderate denaturation of surface proteins that were in immediate contact with the sodium lactate during treatment application. This denaturation would result in decreased water-holding capacity in the proteins, and subsequent decreased cooking yields. The water holding capacity of meat and poultry proteins decreases at or near pH 5.00, which is their isoelectric point. The pH of the NaL-5.00 treated breast meat ranged from 5.02 on Day 0 to 5.41 on Day 10 (Table 3).

**Microbiological Evaluation**

The APC increased as storage time increased, but remained lower for all sodium lactate treated breast meat through 10 d (Table 3). Sodium lactate treated breast meat resulted in significantly lower ($P < 0.05$) APC after 7 and 12 d, when compared to the control treatment. The NaL-5.50, and NaL-5.00 were the most effective treatments for retarding microbial growth on the breast meat. The intense off-odor and moderate off-flavor detected in the control breast meat samples after 10 d storage might be largely attributed to the growth and proliferation of microorganisms. Poultry is usually considered to be spoiled when the microflora reaches log$_{10}$ 7 to log$_{10}$ 8 cfu/g (Ayres, 1960). The APC was log$_{10}$ 8.93 cfu/g for the control breast meat samples after 10 d storage.

Although the pH values of the control and NaL-7.30 samples were similar ($P > 0.05$) in texture through 10 d storage (Table 2). All Warner-Bratzler shear values were in the range of 1.73 to 2.84 kg, which was indicative of very tender breast meat (Lyon and Lyon, 1991). The corresponding panelist scores were 6.11 to 7.03, which were indicative of moderately tender to very tender breast meat. A comparison of the panelists responses for tenderness (Table 1) and Warner-Bratzler shear values (Table 2) revealed that the sodium lactate treatments had no adverse effects on texture of the breast meat.
Day 12, the APC were significantly lower ($P < 0.05$) for samples treated with NaL-7.30. The antimicrobial effect of sodium lactate treatments was enhanced as the pH of the solutions decreased, indicating that pH influenced the reduction in microbial growth. In addition, the fact that antimicrobial activity was also observed in the NaL-7.30 treatment in which no pH was adjusted, suggested that the sodium lactate treatment also exerted antimicrobial effects on the microflora of the breast meat. Grau (1980) determined that sodium lactate solutions at pH 5.70 or lower inhibited the anaerobic growth of *Brochothrix thermosphacta* in beef muscle extract samples stored at 25 and 5°C. Williams et al. (1995) determined that the effectiveness of sodium lactate in extending the shelf life of fresh catfish fillets increased as the pH of the treatment solutions approached the pKa (the pH at which the concentration of dissociated and undissociated acid is equal for a weak acid) value of 3.86 for lactic acid. However, at pH values of 4.00 to 5.00, the acceptability of the fillets decreased due to denaturation of proteins and development of acidic flavor. As the pH of the sodium lactate solutions decreased, the concentration of undissociated lactic acid and antimicrobial properties increased. However, increasing lactic acid concentration (i.e., pH 4.00, 4.50, and 5.00) resulted in discoloration and denaturation of the fish proteins. The final calculated concentrations, using the Henderson-Hasselbach equation (Segel, 1976), of sodium lactate and lactic acid in the treatment solutions for the breast meat were 1.08 and 0.03 M, respectively, for pH 5.50; and 1.24 and 0.09 M, respectively, for pH 5.00.

This study revealed that sodium lactate treatment solutions with pH adjusted to 5.50 and 5.00 were most effective in retarding growth of the spoilage microflora on the breast meat. The slight sodium, metallic, or acidic off-flavors detected when these treatments were applied will probably be minimized or eliminated in poultry products systems in which seasonings such as salt or spices are employed. Panelists detected no off-flavor (i.e., sodium, metallic, or acidic) in a cooked vacuum packaged roast beef product containing 0.5% sodium chloride, and 3% sodium lactate (Papadopoulos et al., 1991).

### REFERENCES


