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EFFECTIVENESS OF SODIUM LACTATE AND GLUCONO-DELTA-LACTONE COMBINATIONS AT PRESERVING RESTRUCTURED, NON-CURED, NON-REFRIGERATED PORK ROLLS

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BACKGROUND

Non-cured, cooked poultry and beef products are becoming more popular. Currently, there are few if any non-cured, cooked pork products. Part of this deficiency is the absence of additives, like sodium nitrite, that are capable of preventing warmed over flavor and inhibiting microbial growth. Sodium lactate and glucono-delta-lactone exhibit antimicrobial activity and may be useful in replacing sodium nitrite.

Sodium lactate delays the growth of *Listeria monocytogenes* and *Pseudomonas fragii* and the toxin production of *Clostridium botulinum* (Shelef and Yang, 1991; Harmayani et al., 1991; Maas et al., 1989). It has USDA approval in meat products as a flavor enhancer at 2.0% and an antimicrobial agent at 4.0% (Tuley, 1989). Papadopoulos and others (1991) reported that consumers preferred the beef flavor and overall flavor of beef roasts containing 3.0% sodium lactate when compared to roasts with no sodium lactate.

Glucono-delta-lactone (gluconic acid lactone, GDL) is commonly used in some fermented sausages at 0.5% and is allowed in Genoa salami at 1.0% (Romans et al., 1977). It is an acidulant and does not impart strong acid flavors to food. El-Shenawy and Marth (1990) observed that 0.4% GDL reduced the growth of *Listeria monocytogenes* in tryptose broth at 13°C. In reconstituted milk, 1.5% GDL was required to reduce growth at 13°C.

Preliminary research in our facilities revealed that sodium lactate and GDL exhibit synergistic interactions in inhibiting the growth of *E. coli* O157:H7, *Salmonella typhi*, *Yersinia enterocolitica*, *Listeria monocytogenes* and *Staphylococcus aureus* when incubated in cooked meat media at 35°C. Combinations of GDL (0.25 and 0.5%) and sodium lactate (1.5 and 3.0%) were more effective at inhibiting the growth of the pathogens investigated than either sodium lactate or GDL alone. The most effective combination was 0.5% GDL and 3.0% sodium lactate.

OBJECTIVES

This research was undertaken to evaluate the effectiveness of sodium lactate and glucono-delta-lactone combinations in preserving restructured, non-cured pork rolls stored at room temperature.

MATERIALS AND METHODS

Restructured pork rolls were produced from conventionally processed hams, loins and shoulders from sow carcasses trimmed of excess fat and connective tissue. All pork rolls were formulated to consist of 0.75% sodium chloride, 0.4% sodium tripolyphosphate and a 5% final fat content. The meat block contained 80% coarse ground lean and 20% emulsion (consisting of lean shanks and knuckles). Water was added at 11% of the raw product's weight to compensate for a 90% cooking yield. Treatments included: 1) control: no other additives; 2) nitrite control: sodium nitrite (0.0156%) and sodium erythorbate (0.055%); 3) 0.25% glucono-delta-lactone and 1.5% sodium lactate; 4) 0.25% glucono-delta-lactone and 3.0% sodium lactate; 5) 0.5% glucono-delta-lactone and 1.5% sodium lactate; 6) 0.5% glucono-delta-lactone and 3.0% sodium lactate. Rolls were cooked in a Vortron smokehouse (Beloit, WI) to an average internal temperature of 71°C. Smokehouse air temperature and pork roll internal temperatures were monitored with a Multipoint Recorder/Logger (Esterline Angus, Co) with copper-constantan thermocouples. Final smokehouse air temperature had a 5°C range and final internal temperatures had a 5-10°C range. The pork rolls were chilled overnight (0-3°C), vacuum packaged in Cryovac #B450 (Cryovac, W.R. Grace and Co) bags, heat shrunk, then stored at room temperature (18-22°C).

Microbial analysis consisted of aerobic and anaerobic plate counts and evaluation for the presence of *Salmonella* on three pork rolls at 3 day intervals for 15 days. Aerobic plate counts were on plate count agar (Difco #0479-17-3) at 35°C. Anaerobic plate counts were determined on anaerobic agar (Difco #0536-17-4) in Gas Pak chambers with an H_2 and CO_2 atmosphere at 35°C. Presence of *Salmonella* was determined with a 24 hr enrichment (35°C) in lactose broth (Difco #0004-17-0), selective enrichment (35°C) in selenite cystine (Difco #0687-15-3) and tetrathionate broths (Difco #0104-17-6), and enumeration on XLD (Difco #0788-01-7) and bismuth sulfite (Difco #0073-01-1) agars incubated at 35°C. Presumptive *Salmonella* evaluations were confirmed with triple sugar iron (Difco #0265-01-9) and lysine iron agar (Difco #0849-01-4) slants (35°C).

Moisture, fat, ash and protein were determined using three pork rolls from each treatment. Analysis procedures were: moisture:oven drying; fat:ether extraction; protein:macro kjeldahl; and ash:muffle furnace. Water activity (A_w) was measured at 0, 6 and 12 days with an Aqualab model CX2 (Decagon Devices, Inc) water activity measuring device. Pork roll pH was evaluated at 3 day intervals with a portable Oyster (Extech Instruments) pH meter. Thiobarbituric acid (TBA) analysis (Rhee, 1978) was used to evaluate oxidative rancidity at 3 day intervals.

An 18 member trained sensory panel evaluated the product at day 0 for juiciness, pork flavor intensity, saltiness and off-flavors. Juiciness and pork flavor intensity were rated on an 8 point scale with 8=extremely juicy or intense and 1=extremely dry or bland. Saltiness was evaluated on an 8 point scale with 8=none and 1=extremely salty. Off-flavor was rated on a 6 point scale with 6=none and 1=extreme. Samples were served at room temperature without reheating.

Statistical analysis utilized the general linear models program (PROC GLM) of SAS (SAS Institute, 1985). Treatment differences were

determined with analysis of variance. Sensory panel results were analyzed by analysis of variance and differences in means were determined with Student-Newman-Keuls test.

RESULTS AND DISCUSSION

Aerobic and anaerobic growth followed similar trends. The control exceeded 10^4 CFU/g at day 6 and $\geq 10^5$ at days 9-15. The nitrite control reached 10^5 CFU/g at 9 days of storage and these levels were maintained at days 12 and 15. All of the sodium lactate and GDL combinations maintained $\leq 10^2$ CFU/g, with the 1.5% sodium lactate and 0.25% GDL treatment reaching 10^3 CFU/g at day 15. Enrichment for *Salmonella* resulted in none being identified at day 0. At days 3 to 15 there was sporadic appearance of *Salmonella* in all treatments and replications. This may be the result of slightly insufficient heating combined with elevated storage temperature, which would allow injured organisms to survive storage when refrigerated storage would not.

Average proximate analysis were as follows: moisture:69.86%; fat:4.52%; protein:21.25%; and ash:2.66%. The water activity values for the controls were higher ($P<0.01$) than the sodium lactate and GDL treatments. The controls exhibited initial A_w values of 0.980 and final A_w values of 0.977. The GDL and sodium lactate treatments exhibited initial A_w values of 0.971 to 0.974 and final A_w values of 0.965 to 0.972. All the water activity values were within the growth range of both spoilage and pathogenic bacteria, and the differences were small. However, the slight reduction in A_w caused by GDL and sodium lactate may contribute to preservation.

The pH of treatments with 0.25% GDL and the controls were higher ($P<0.01$) than the pH of treatments with 0.5% GDL. The treatments with 0.25% GDL and the controls ranged in pH from 6.0 to 6.1 during 15 days of storage. Treatments with 0.5% GDL ranged in pH from 5.88 to 5.92 for 0 to 9 days of storage. The pH of the 0.5% GDL and 3.0% sodium lactate treatment increased to 5.99 by day 15. The differences in pH caused by the addition of 0.5% GDL were small, however reduced pH may contribute to enhanced preservation.

Thiobarbituric acid analysis revealed significant ($P<0.01$) variations in TBA values due to replication, treatment, day and treatment by day interactions. Overall treatment averages indicate that the control had the value of 0.184, the GDL and sodium lactate treatments had median values of 0.155 to 0.162 and the nitrite control had the lowest value of 0.120. During storage TBA values never exceeded 0.300 suggesting that rancidity was not a problem in this particular product. The overall low TBA values were associated with the low fat content of the product.

The sensory panel rated all of the pork roll treatments as moderately juicy, slightly intense in flavor, slightly salty to salty and threshold to slight in off-flavors. The GDL and sodium lactate treatments were scored as more ($P<0.05$) intense in pork flavor and more ($P<0.05$) salty than the controls. The 3.0% sodium lactate treatments exhibited more ($P<0.05$) off-flavors than the controls.

CONCLUSIONS

Sodium lactate and GDL combinations are effective preservatives for non-cured, non-refrigerated, restructured pork rolls. They inhibited aerobic and anaerobic growth, however they allowed the survival of *Salmonella* indicating a need for final internal temperatures above 71°C. Slight reductions in pH and A_w accompanied the sodium lactate and GDL combinations. The pH and A_w values for the sodium lactate and GDL combinations were not low enough to inhibit microbial growth. Therefore, pH and A_w are only minor mechanisms for preservation.

Sensory evaluation revealed only slight variations in pork flavor intensity, saltiness and off flavor between all of the treatments. Sodium lactate and GDL reduced the development of oxidative rancidity when compared to the control. However, they were not as effective as nitrite. The results suggest that sodium lactate and GDL combinations reduce the development of rancidity at low fat levels.

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