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SODIUM LACTATE, SODIUM CITRATE, SODIUM ACETATE AND SODIUM PROPIONATE EFFECTS ON THE SENSORY, MICROBIOLOGICAL AND CHEMICAL CHARACTERISTICS OF VACUUM-PACKAGED GROUND BEEF. J.V. MACA, R.K. MILLER, AND G.R. ACUFF. Department of Animal Science, Texas A&M University, College Station, TX, USA

INTRODUCTION: As more and more consumers turn to convenience foods as sources of nourishment, the safety of these foods becomes a sizable issue. Though microbiological hazards can often be avoided simply by employing proper cooking and holding practices, it is not always known whether these practices are strictly followed. The addition of non-meat ingredients to improve the shelf life of precooked meat products both from a sensory as well as microbiological standpoint is a standard industry practice. Nitrites, salts, organic acids and salts of organic acids have been have been studied extensively for use as a means for controlling microbial growth in meats (Brewer et al., 1991; Lamkey et al., 1991; Maas et al., 1989; Papadopoulas et al., 1991). Other salts of organic acids such as sodium acetate, sodium citrate and sodium propionate have been used in other food products to control microbial growth, preserve color, solubilize proteins and to prevent mold growth. Little is known, however, about the usefulness of these salts as mechanisms to increase shelf life of meat products. The objectives of this study, therefore, were to determine the effects of sodium acetate, sodium citrate, sodium lactate and sodium propionate at different levels and in different combinations in vacuum-packaged ground beef patties on sensory attributes, color, microbial growth, lipid oxidation, pH and water activity when stored at 4°C for 0, 7, 14, 21 and 28 d.

MATERIALS AND METHODS: Coarse ground beef (25% fat) was obtained from a commercial beef processor and ground using a 0.48-cm plate. Ground beef came from two different production days to facilitate two replicates that were processed on different days. Eighteen treatments were defined as: 1) control-no added ingredients; 2) sodium lactate treatments containing either 2, 3, or 4% sodium lactate in the final product; 3) sodium lactate (2, 3, or 4%) plus 0.1 or 0.2% sodium propionate; 4) sodium citrate treatments containing 0.1, 0.2, or 0.3% sodium citrate in the final product; 5) sodium acetate treatments containing 0.1, 0.2, or 0.3% sodium citrate in the final product; and 6) lower levels of ingredients will be used in combination (2% sodium lactate + 0.1% sodium citrate + 0.1% sodium acetate and 2% sodium lactate + 0.1% sodium citrate + 0.1% sodium acetate + 0.1% sodium propionate). Ground beef patties (113 g) were portioned and stored in vacuum-packaged B540 bags at 4°C. The patties were evaluated after 0, 7, 14, 21 and 28 d of storage. Vacuum bags used in this study were 3.2 mil saran®-coated polyvinyl chloride with an OTR of 3-6 cc $O_2/m^2/24h$, atm. at 4.4°C and 0% relative humidity (RH) and a moisture vapor transmission rate of 0.5-0.6 g/100 $in^2/24h$ at 37.78°C and 100% RH. Total aerobic plate count (APC) was determined in duplicate using serial dilutions from 25-g samples which were spread-plated on Tryptic Soy Agar (Difco) and incubated for 48 h at room temperature. A six-member trained flavor and texture descriptive attribute panel was used to evaluate the ground beef patties. Panel members were selected and trained based on the procedures of Meilgaard et al. (1991). Samples were evaluated for aromatics, tastes, mouthfeels, aftertastes and texture attributes using the Spectrum™ Universal Intensity Scale (0=none and 15= extremely intense; Meilgaard et al., 1991). Ground beef samples were cooked in electric skillets (176°C cooking temperature) to an internal temperature of ~71°C . Four ~1.27 cm sections of each sample were served to each panelist, with 18 samples being evaluated per day. Objective color evaluation was determined using the HunterLab colorimeter. Hunter L, a and b values were obtained on a minimum of 4 locations per raw ground beef sample using the procedures of AMSA (1991). Ground beef samples also were evaluated by a trained descriptive attribute sensory panel for surface color as described by AMSA (1991). Water activity was determined following the procedures of Prior (1979) using a Hygrodynamics American Instruments hygrometer (Silverspring, MD). Readings were converted from relative humidity to water activity by dividing by 100. Lipid oxidation was measured using procedures described by Tarladgis et al. (1960) as modified by Rhee (1978). Measurements of pH were conducted according to AOAC (1984) procedures. Data from this experiment was analyzed by ANOVA using SAS (1988) with a significance level of $\alpha<0.05$. The design of the experiment was an 18x5 factorial arrangement with 2 replications. The interaction between treatment and storage day also was tested. Significant means for flavor and color sensory data were separated using Bonferroni's method. Significant means for all other data were separated using Tukey's Studentized Range Test ($\alpha<0.05$).

RESULTS AND DISCUSSION: Treatment had no effect on cooked beef/brothy, cooked beef fat, serum/bloody, liver and browned aromatics, metallic and astringent feeling factors, sour taste, springiness, cohesiveness, hardness, fracturability, Hunter a and b values and chroma. Ground beef patties containing 3% sodium lactate with or without sodium propionate and combination treatments had lower sensory scores for grainy, cowy, cardboard and soured aromatics, higher lean color scores, and were juicier than control , sodium citrate, or sodium acetate ground beef patties. Ground beef patties from all treatments were denser than control patties. Although the treatment effect for Hunter L values was significant, differences were not detected when means were separated. All treatments containing sodium lactate tended to be lighter in color (lower L values) than ground beef patties from all other treatments. Water activity was highest in patties from the control and sodium acetate and sodium citrate treatments. Storage day had no effect on liver, browned and burnt aromatics, astringent feeling factor, hardness, fracturability or water activity. Least squared means for storage day effect for sensory attributes and Hunter color evaluation are listed in Tables 1 and 2. Cooked beef/brothy and grainy aromatics, and Hunter a values increased through storage day 14

and then dropped slightly and leveled off with subsequent storage. Cowy and cardboard aromatics, sour taste, metallic feeling factor, cohesiveness, denseness and Hunter L and b values increased with storage. Lean color scores decreased with storage. The interaction between treatment and storage day was significant for pH. For all treatments, pH declined with storage and treatments containing sodium lactate had higher pH values than all other treatments. The interaction between treatment and storage day was significant for total APC. Total APC for treatments containing 3% sodium lactate with or without sodium propionate were lowest and did not change with storage. Treatments containing sodium citrate, sodium acetate, 2% sodium lactate, combination treatments and the control had a 3 log increase in total APC with storage. TBA values were not practically different across storage day and between treatments although this interaction was significant ($P < 0.0001$).

CONCLUSIONS: Results from this study indicated that sodium lactate levels of 3 or 4% and sodium lactate (3 or 4%) with sodium propionate combinations extended the shelf life of vacuum-packaged ground beef by reducing total microbial growth, decreasing off flavor development and helping to maintain positive flavor notes and color during storage.

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Table 1. Least squared means for storage day effects from sensory evaluation.

Storage day	Cooked beef/ brothy aromatic	Serum/ bloody aromatic	Grainy aromatic	Cowy aromatic	Cardboard aromatic	Soured aromatic	Salt taste	Sour taste	Sweet taste
0	3.22^{a}	0.23^{ab}	0.06^{ab}	0.63^{a}	0.03^{a}	0.86^{ab}	2.56^{a}	1.02^{bc}	0.81^{ab}
7	3.88^{b}	0.30^{b}	0.06^{ab}	0.76^{bc}	0.06^{a}	0.82^{a}	2.95^{b}	0.85^{a}	0.88^{ab}
14	3.98^{b}	0.16^{a}	0.09^{b}	0.80^{cd}	0.13^{a}	1.00^{b}	2.97^{b}	0.90^{ab}	0.93^{b}
21	3.46^{ac}	0.13^{a}	0.04^{ab}	0.67^{ab}	0.31^{b}	1.00^{b}	3.09^{b}	0.98^{bc}	0.80^{a}
28	3.64^{bc}	0.20^{ab}	0.01^{a}	0.86^{d}	0.32^{b}	1.02^{b}	2.93^{b}	1.05^{c}	0.91^{ab}

$^{a-c}$Means within a column with the same superscript are not different ($P < 0.05$).

Table 2. Least squared means for storage day effects from sensory evaluation and Hunter color evaluation.

Storage day	Springiness	Cohesiveness	Juiciness	Denseness	Lean color	Hunter L	Hunter a	Hunter b
0	6.67^{a}	6.38^{a}	3.73^{a}	6.62^{a}	6.82^{b}	40.53^{b}	14.22^{bc}	11.64^{b}
7	7.63^{b}	6.75^{b}	3.88^{b}	6.80^{bc}	6.82^{b}	40.48^{b}	13.44^{c}	11.32^{b}
14	6.72^{a}	6.82^{bc}	3.66^{a}	6.86^{c}	6.55^{ab}	43.32^{a}	15.20^{a}	12.58^{a}
21	6.74^{a}	6.83^{bc}	3.62^{a}	6.68^{ab}	6.52^{a}	43.64^{a}	15.09^{ab}	12.67^{a}
28	6.80^{a}	7.04^{c}	3.70^{a}	6.74^{abc}	6.64^{ab}	43.70^{a}	14.76^{ab}	12.72^{a}

$^{a-c}$Means within a column with the same superscript are not different ($P < 0.05$).