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Effects of sodium lactate and acetic acid derivatives on the quality and sensory characteristics of hot-boned pork sausage patties

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ABSTRACT

Sodium lactate and acetic acid derivatives were evaluated for their effects on color retention, microbial growth, and sensory attributes of hot-boned pork sausage patties. Treatments included: (a) sodium lactate (L), (b) buffered vinegar (V), (c) sodium lactate and vinegar mixture (LV), (d) control with BHA/BHT (C), and (e) negative control (NC). Treatments L and LV decreased TPC at day 14 and day 16 when compared to control samples and reduced bacterial numbers up to 18 days. In addition, use of lactate and vinegar increased ($P<0.05$) acceptability and juiciness and reduced ($P<0.05$) off-flavor and rancidity when compared to control treatments at day 14. These results revealed that the L and LV sausage patties retained sensory acceptability and shelf-life quality from day 14 through day 17 as opposed to other treatments. Additionally, sausage patties with LV maintained redness and sensory quality throughout 17 days of shelf-life, as compared to other treatments that retained color and quality for 14 days.

1. Introduction

Semi-processed meats such as fresh pork sausage that are held under refrigerated retail conditions are limited in shelf-life expectancy. Consumer acceptability of fresh pork sausage declines due to the decrease of red color and development of off-odors during retail storage due to microbial growth and/or lipid oxidation. Antimicrobials and antioxidants are sometimes added to fresh processed meats to extend shelf-life. Many studies have been conducted on the antimicrobial properties of sodium lactate and acetic acid in the form of spray washes on carcasses (Dorsa, Cutter, & Siragusa, 1998; Hardin, Acuff, Lucia, Oman, & Savell, 1995; Latha, Sherikar, Waskar, Dubal, & Ahmed, 2009). Sodium lactate is a salt which acts as an undissociated acid, passing through the microbial membrane to acidify the cellular interior (Carpenter & Broadbent, 2009; Hunter & Segel, 1973). As a result, intracellular pH and cell metabolism may decline rapidly as organelles denature, and cell death may occur. Lamkey, Leak, Tuley, Johnson, and West (1991) produced fresh pork sausage chub packs with 3.0% sodium lactate which extended shelf-life up to two weeks over control pork sausage chubs. An extensive study by Brewer, McKeith, Martin, Dallmier, and Meyer (1991) reported that sodium lactate (2–3%) is responsible for reducing microbial growth, pH decline, and uncharacteristic off-flavors in pork sausage for 7–10 days when compared to a control. Acetic acid is commonly known as vinegar and like sodium lactate has been shown to have antimicrobial properties. Numbers of *Escherichia coli* 0157:H7 and *Salmonella typhimurium* were reduced by 0.1 log CFU (colony forming units) to 4.67 log CFU/cm^2 using an acetic acid spray wash (Cutter, Dorsa, & Siragusa, 1997). Ita and Hutkins (1991) reported a 4 log reduction of *Listeria monocytogenes* cells held at a low pH (3.5) in acetic acid, while bacteria cells in lactic acid were only reduced by one log. Ita and Hutkins (1991) hypothesized that not only did acetic acid work to acidify the cell interior, but is thought to interrupt bacterial proton pumps in the cell membrane responsible for ion regulation. While use of acetic acid may reduce microbial load there are instances of development of meat discoloration.

Oxidative rancidity is the second major cause of reduced quality for fresh meat, especially higher fat products like pork sausage. Rancidity occurs through the reaction of unsaturated fats with oxygen (Cheng, Wang, & Ockerman, 2007; Kramlich, Pearson, & Tauber 1973). This reaction is influenced by heat, light, and pro-oxidant compounds found in the ingredients, such as salt (Price & Schweigert, 1978). Oxidative rancidity can be controlled/retarded by adding antioxidants. The more common antioxidants which are widely used are butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), and propyl gallate. However, synthetic antioxidants are heavily regulated and usage levels are found in the Code of Federal Regulations.

The objective of this study was to evaluate the use of sodium lactate, acetic acid, and a combination of sodium lactate and acetic acid in fresh pork sausage to determine their effectiveness at extending

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shelf-life by reducing microbial growth and maintaining retail display and sensory acceptability. Shelf-life impact was determined by measuring the amount of bacterial growth over time, deterioration of color in simulated retail conditions, oxidative rancidity over time, and identifying and describing sensory characteristics.

2. Materials and methods

2.1. Meat processing and sample preparation

Three sows (3–4 years of age) were purchased (Prestage Farms, West Point, MS). One sow was used per replication (3) to formulate treatments to assure that there was limited variability among treatments within each replication. Each sow was conventionally harvested according to approved humane slaughter practices under USDA inspection and processed at the Mississippi State University Meats Laboratory. Immediately after exsanguination and proper dressing procedures (skinning), the left side of each carcass was de-boned. Roughly 45 kg of each boneless left side was coarse ground (Model 80055 Mixer Grinder, Hollymatic Co., Countryside, IL) with fresh pork sausage seasoning (Rebel Country Sausage Seasoning, Rebel Butcher Supply Co., Inc, Jackson, MS). A random sample from each replication was analyzed to determine fat percentage (LabWave 9000™ Model FES. CEM Corporation. Matthews, N.C.). Leaf fat from the same carcass (within each replication) was added to increase fat percentage to an average of 23% as needed. Five 9 kg batches of coarsely ground pork were randomly assigned to one of five treatment groups: 2.5% sodium lactate 60% solids, pH 6.5–8.0 (L) (ULTRA-PURE SL-75, Hawkins, Inc., Linden, NJ), 2.5% buffered vinegar pH 6.5–8.0 (V) (Buffered Vinegar-experimental, Hawkins, Inc., Linden, NJ), 2.5% sodium lactate {52%} and vinegar {48%} mixture (LV) (VINLAC-DS2, Hawkins, Inc., Linden, NJ), a control with 0.02% BHA/BHT (C), and a negative control with no antioxidant or antimicrobial additives (NC). All ingredients were uniformly distributed and mixed with the coarse ground pork prior to each batch being reground through a 4 mm plate with a four blade knife (80055 Mixer-grinder, Hollymatic Co., Countryside, IL) and stuffed (Risco I-36016 Thiene, Vincenza, Italy) into 7.62 cm diameter plastic tubes (Interstate Packaging, White Bluff, TN), labeled and frozen overnight at −23 °C. All equipment was cleaned between each treatment for all replications. The frozen logs were sliced to 1.27 cm thickness and packaged with six patties per labeled polystyrofoam tray (White Foam Meat tray—8½″ × 6½″ × ½″, Instawares, LLC., Kennesaw, GA) and overwrapped (Meat Stretch, LINPAC Filmco, Inc., Aurora, OH). The overwrap O_2 transmission rate = 4300 cc/day/m^2/atm and the water vapor transmission rate = 7.5 cc/m^2/day. The overwrapped trays with frozen sausage patties were randomly selected, placed and maintained under simulated retail lighting (753 lux) conditions continually until evaluation time for the respective evaluations. The packages were maintained at a temperature of 1 to 2 °C for up to 18 days to simulate temperature and holding times found in refrigerated display cases in tested local retail markets. A separate tray(s) of sausage patties was dedicated for each data point collection for each replication and each treatment.

2.2. Total plate counts

Sausage samples were subjected to microbiological examination to enumerate total plate counts (TPC), *E. coli* and coliforms on days 0, 7, 14, 16, and 18 of shelf life. Duplicate 25 g samples from each treatment were weighed into sterile stomacher bags (BA6141/5TR filter bag, Stomacher® Lab System, Seward, U.K.). The samples were then diluted with 225 ml of 0.1 M (pH 7.5) phosphate-buffer saline before homogenizing for 1 min (Stomacher® 400 Circulator Seward, U.K.) then serially diluted in 9 ml tubes of 0.1 M phosphate-buffered saline to obtain countable plates. Samples were spread plated on Tryptic-Soy agar (Becton Dickson, Sparks, MD) and incubated at 34 °C for 48 h prior to counting colonies. On days 0 and 18, samples were plated onto *E. coli*/Coliform Count Plate Petrifilm™ (3 M Petrifilm™, St. Paul, MN), and incubated at 34 °C for 24 h to determine *E. coli* plate counts. Total plate counts (TPC) and *E. coli*/coliforms were reported as log CFU/g.

2.3. Instrumental color analysis

The surface of sausage patty samples was evaluated for CIE L^* (lightness), a^* (redness), and b^* (yellowness) using a Chroma Meter CR-400 (Minolta Camera Co. Ltd., Osaka, Japan Serial No. C8202489) that was calibrated using a standard white calibration plate (Model No. 20933026, Japan). On days 0, 4, 7, 11, 14, 16, and 18 a randomly selected package of each treatment was chosen at each evaluation day. Three patties from each tray were then selected and removed from the tray, and three separate readings were taken on each of the patties for a total of nine measurements. The nine readings from each treatment sample were averaged for a final color reading and used in statistical analysis.

2.4. Thiobarbituric acid reactive substance values

Oxidative rancidity of the sausage patties was determined by using an extraction method of Spanier and Traylor (1991). Standard solutions were prepared containing 0.05 ml sodium dodecyl sulfate (SDS), 5.0 ml solution III (0.1 g propyl gallate and 0.2 g EDTA), and increasing concentrations of tetramethoxypropane (TMP). Standard solutions were used to compare color pigment increase associated with increased pigment in oxidized meat products. A 5 g sample of each treatment, control, and negative control was added to 65 ml of distilled water, 0.01 ml of 10% SDS, and 10 ml of solution III. Mixtures were produced in duplicate and homogenized. Standards and homogenates were transferred to test tubes in 1 ml increments and 4 ml of solution I (3.75 g thiobarbituric acid, 5.06 g SDS, and 119 ml glacial acetic acid; adjusted to pH 3.4) was added to the sample prior to placement in a 95 °C water bath for 1 h. After cooling, 5 ml of solution II (15:1 solution; n-butanol and pyridine) was added to each sample and standard tubes prior to centrifugation (Centrific Model 228, Fisher Scientific, Fair Lawn, NJ) at 1100 × *g* for 15 min. After centrifugation, the absorbance of the top layer was measured using a UV–VIS Spectrophotometer (UV 1201, Shimadzu, Kyota, Japan and Columbia, MD, USA) set at 532 nm, and mg MDA/kg meat was determined for standards and samples using a standard curve.

2.5. Descriptive sensory analysis

An eight member trained sensory panel evaluated the appearance, aroma, oral texture, basic tastes, flavor and overall sensory integrity of cooked pork sausage patties on days 0, 7, 14, and 17. Selection and training of panelists was conducted using the Quantitative Descriptive Analysis (QDA®) method (Meilgaard, Civille, & Carr, 2007). Panelists participated in six 1-hour training sessions to evaluate pork sausage for specific sensory components of the product within the categories of appearance, aroma, oral texture, basic tastes, flavor and overall quality. Previously identified descriptors (Flores, Armero, Aristoy, & Toldra, 1999; Meilgaard, Civille, & Carr, 2007; Pegg & Shahidi, 2007; Rødbotten, Kubberød, Lea, & Ueland, 2004) and terms identified during training sessions were utilized for sensory evaluation of fresh pork sausage patties (Table 1). Panelists' training sessions were held in a group discussion atmosphere to develop final descriptors for consistency in scoring samples. After training, sensory testing was replicated and evaluation was conducted on days 0, 7, 14, and 17 of shelf-life for all three replications. The descriptors were measured using a 15-point intensity line scale; 0 = not detected and 15 = extremely strong.

Sausage patties were prepared by frying on a griddle top (Griddle 442A, Toastmaster Inc., Booneville, MO). The griddles were preheated