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Impact of sodium lactate and vinegar derivatives on the quality of fresh Italian pork sausage links

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ABSTRACT

Sodium lactate and acetic acid derivatives were evaluated for their impact on fresh Italian pork sausage using commercial trimmings. Analysis over storage included total plate count (TPC), TBARS, sensory analysis, cooking loss, pH, and color. Treatments included: (a) vinegar and sodium lactate mixture (V), (b) sodium lactate (S), (c) positive control with BHA/BHT (B) and (d) negative control, seasoning only (C). Treatments S and V had lower TPC ($P < 0.05$) from days 5 to 14 when compared to B and C. TBARS values increased ($P < 0.05$) for C, S, and V while B did not change ($P > 0.05$) over time. While CIE a* surface values for redness generally decreased over storage time for all treatments, B maintained more redness. There were few major differences in descriptive sensory evaluation over time, but S and V precluded early onset of rancidity, oxidation and other off-flavors contrary to some of the analytical results. Of consumers tested, 85.6% rated all treatments between like slightly and like very much.

1. Introduction

Fresh Italian pork sausage is susceptible to microbial and oxidative spoilage off-flavors. The rate of spoilage greatly affects the overall quality and freshness of sausage, which influence consumer purchase decisions. Meat preservation is typically accomplished through ingredient technology, freezing and refrigeration. In pre- and post-harvest operations, organic acids have a history of being used as additives and preservatives to prevent spoilage and extend the shelf-life of perishable food (Ricke, 2003). Organic acids and their salts, such as sodium lactate and acetic acid (acid component of vinegar), are associated with delaying bacterial spoilage, increasing shelf life, and maintaining color and sensory quality longer than normal sausage products. Such benefits may extend market shelf-life and therefore profitability. In poultry sausages, sodium lactate inhibited the growth of aerobic psychrotrophic bacteria and lactic acid bacteria during refrigerated storage, and maintained color and sensory properties longer than the control (Cegieleska-Radziejewska & Pikul, 2004). In a study of sheep and goat meat, Dubal et al. (2004) sprayed forequarters with 2% lactic acid and 1.5% acetic + 1.5% propionic acid combination which caused minimal changes in color and odor while reducing total viable counts of *Staphylococcus aureus*. Organic acids have bactericidal and bacteriostatic properties, while the salts are primarily bacteriostatic (Smulders & Greer, 1998). The uncharged, undissociated state of the acid molecule is primarily responsible for antimicrobial activity (Theron & Lues, 2007).

Secondly, meat and meat products are susceptible to deterioration by lipid oxidation and the production of rancid off-flavors, especially in sausage due to its high fat content. Fresh sausage is often times more vulnerable to oxidative rancidity than fresh whole muscle or cured meat due to high temperature and oxygen exposure during processing (Sebranek, Sewalt, Robbins, & Houser, 2005). Not only is exposure to oxygen a problem, meat can oxidize if exposed to heat, light, salt, iron, or other elements. Various cooking parameters and conditions can cause increased oxidation in sausage products as well. Antioxidants can be added to improve the flavor of meat and preserve its color (Castigliego, Armani, & Guidi, 2012). Antioxidants can extend the shelf life of refrigerated products by 2–5 days (Smith, 2012). Approved antioxidants must stabilize fat at low concentrations as well as be tasteless, odorless, and non-toxic to humans (Romans, Costello, Carlson, Greaser, & Jones, 2001). Tocopherols, butylated hydroxyanisole (BHA), and butylated hydroxytoluene (BHT) are all phenolic substances that are effective antioxidants (Feiner, 2006).

Two sources of raw materials are used to produce fresh pork sausage: trimmings from pork cutting operations and boneless pork derived from boning entire hog carcasses (usually sows) (Romans et al., 2001). Many larger sausage facilities have the resources to use hot-boned, whole hog meat for sausage processing, but most small processing facilities purchase fresh or frozen trimmings. While the use

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of purchased trimmings incorporates animal source and quality variation, the use of fresh trimmings is normal for small manufacturing processes and represents numerous products in the retail market.

The objective of this study was to determine the quality and sensory parameters of fresh Italian sausage links made with commercial fresh pork trimmings over storage time in a simulated retail display using sodium lactate and a sodium lactate and vinegar mixture. The objective was accomplished through analysis over storage using microbial total plate count (TPC) methods, oxidative rancidity (TBARS), cooking loss, pH, sensory analysis (descriptive and consumer), and color deterioration (CIE L* a* b*).

2. Materials and methods

2.1. Meat processing and sample preparation

Fresh pork trimmings (72/28-lean/fat percentage) were purchased three separate times with each purchase representing a separate replication (Polk's Meat Products, Magee, MS) and transported to the Mississippi State University Meat Laboratory. Pork trimmings were ground through a 25.4 mm plate with a four blade knife then reground through a 4 mm plate (Model 80055 Mixer Grinder, Hollymatic Co., Countryside, IL) to obtain a sample for fat percentage analysis (Food Scan™ Lab, Model 78810, Foss, Co., Hillerød, Denmark). Fresh Italian pork sausage was made to the standards outlined by the Code of Federal Regulations. Approximately 45 kg of trimmings was mixed for 2 min with added Zesty Italian sausage seasoning (Zesty Italian Sausage Seasoning, A.C. Legg, Inc., Calera, AL) and coarse ground through a 25.4 mm plate with a four blade knife (Model 80055 Mixer Grinder, Hollymatic Co., Countryside, IL). Four 11 kg batches of coarsely ground pork were randomly assigned to one of four treatment groups: 2.5% sodium lactate, 60% solids, pH 6.5–8.0 (Treatment-S) (ULTRA-PURE SL-75, Hawkins, Inc., Minneapolis, MN); 2.5% sodium lactate {51.5%} and vinegar {48.5%} mixture (Treatment-V) (VINLAC-DS2, Hawkins, Inc., Minneapolis, MN); positive control with 0.02% BHA/BHT in combination at .01% each (considered an industry standard) based on fat content as per the Code of Federal Regulations, (Treatment-B); and a negative control with no antioxidants or antimicrobial additives (Treatment-C). Three-percent chilled water was added to all treatments and controls. The amount of water was adjusted for sodium lactate (S) (60% solids, 40% water) to account for the water in the antimicrobial ingredient. Treatment batches were blended for 2.5 min and reground through a 4 mm plate with a four blade knife (Model 80055 Mixer Grinder, Hollymatic Co., Countryside, IL). The treatments were stuffed (Model RS1040C Risco Vacuum Stuffer, Thiene, Italy) into 32–35 mm diameter natural hog casings (Rebel Butcher Supply Co., Jackson, MS) with a target stuff diameter of 34 mm. The casings were linked (12.7 cm), placed 5 per tray (Cryovac® 4 Processor Tray White 7.25" × 9.25" × 1.25, Cryovac, Inc., Reading, PA) and overwrapped with PVC film (O_2 permeability 780 cm^3/100 $in.^2$/day; water permeability 14 g/100 $in.^2$/day; PVC Stretch Film, LINPAC Packaging — Filmco, Inc., U.S.A.). The sample trays were labeled by treatment, randomly placed and maintained in a walk-in cooler under simulated retail display conditions. The simulated retail display maintained lighting with an average of 880 lx and temperature of 1 to 2 °C calibrated to simulate local retail store environments for up to 18 days.

2.2. Microbial analysis

Aerobic microbial analysis was performed similarly to the method of Bradley et al. (2011) on days 1, 5, 7, 10, 14, and 18 of storage. A sample of ground meat without ingredients was evaluated on day 0 to determine a base microbial count. A 25 g composite sample of each treatment sample was removed from packaging, weighed and placed in a sterile stomacher bag (Classic 400 filter bags, Stomacher® Lab System, Seward, U.K.). The samples were diluted with 225 ml of 0.1 M (pH 7.5) phosphate-buffered saline (MP Biomedicals, LLC, Solon, OH), homogenized for 1 min in a Stomacher® 400 Circulator (Seward, U.K.), and then serially diluted in 9 ml tubes of 0.1 M phosphate-buffered saline to create a countable plate range. Samples were spread plated on pre-poured Tryptic-Soy agar plates (Difco™, Becton Dickson, Sparks, MD) and incubated at 34 °C for 48 h prior to analysis. On days 1 and 18, samples were evaluated using *E. coli*/Coliform Count Plate Petrifilm™ (3 M Petrifilm™, St. Paul, MN) and incubated at 34 °C for 24 h to determine *Escherichia coli* presence or recuperation over time. Total plate count (TPC) and *E. coli*/coliforms were expressed as log numbers of colony forming units/g (CFU/g).

2.3. Thiobarbituric acid reactive substances

Oxidative rancidity of the sausage links was evaluated on days 1, 7, 14 and 18 using the method of Leick, Broadway, Solaiman, and Behrends (2012), a procedure that was modified from Rojas and Brewer (2007). Treatment packages were randomly chosen and three links from the package were homogenized (One Touch Chopper, The Black and Decker Corporation, Towson, MD) for a composite sample. All samples and controls were analyzed in quadruplicate. A standard curve was created for comparative analysis with the samples and blanks to determine TBARS values. All samples were reported as mg malondialdehyde (MDA) per kg of tissue (mg MDA/kg tissue).

2.4. Instrumental color analysis

CIE L* (lightness), a* (redness), and b* (yellowness) were determined using a chroma meter CR-400/410 (Minolta Camera Co. Ltd., Osaka, Japan Serial No. C8202489) that was calibrated using a standard white calibration plate (Model No. 20933026, Japan). Sample packages from each treatment were randomly chosen from the simulated retail display on days 1, 5, 7, 10, 14, and 18. Three links from each tray were chosen for measurement analysis. On the exterior of each link, three measurements were taken on the side facing the lighting for a total of 9 readings.

2.5. pH analysis

pH measurements were evaluated in conjunction with color analysis over storage on days 1, 5, 7, 10, 14, and 18. A pH probe (Fisher Scientific Waterproof Meter, Accument®, Singapore) was inserted into the respective cut links of each treatment that were used for color measurements to determine pH.

2.6. Cooking loss

Sausage links were cooked with 1/4 cup of water in a Teflon pan over medium heat on a gas stove (Viking Professional, Greenwood, MS). Links were cooked in a lidded pan for 5 min on each side. After that period, the lid was removed and links continued to cook until an internal temperature of 77 °C was reached. This method was chosen to simulate home cooking and retail packaging directions and as recommended by industry leaders that manufacture this type product. Before cooking, three links from the package were weighed and recorded. The links were then cooked to a final temperature of 77 °C, placed in foil, and re-weighed for a final weight. Cooking loss was determined using the pre-cooked initial weight and final cooked weight. Weights were adjusted to green weight to account for different levels of liquids added to each treatment.

2.7. Descriptive sensory analysis

Descriptive sensory analysis was performed similarly to the method of Bradley et al. (2011). Each treatment of fresh Italian pork sausage (four) was evaluated by a nine member trained panel with experience