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Shelf-life and processing yields of moisture-enhanced pork loins formulated with "gourmet" salts

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ABSTRACT

Objectives were to determine the effects of an industry-typical (**Control**) and 3 "gourmet" (**Grey** sea, **Pink** rock, and unrefined **Rock**) salts on the processing yields and shelf-life of moisture-enhanced pork loins. Loins (n = 41) were injected with a brine formulated to deliver 0.32 g/100 g of salt in the final product. Twelve loins were selected from each treatment to be cut into chops to undergo 6 d of retail display. Control-injected loins had greater ($P \leq .01$) brine uptake and retention than loins injected with Pink or Rock brines, with Grey-injected loins being intermediate. Control-injected loin chops had reduced ($P \leq .02$) reflectance ratio compared with all other treatments and were redder ($P \leq .02$) than Grey- and Pink-injected chops. At 3, 4, 5, and 6 d of display, control-injected loin chops had greater ($P \leq .05$) hue angle than all other treatments. There was no difference in visual discoloration among salt treatments until 4 d, at which point loin chops injected with control brine were more ($P < .01$) discolored than the other treatments throughout the remainder of the display period. These data suggest high purity salt improves brine retention, but may reduce color stability of moisture-enhanced pork loins.

1. Introduction

Salt, typically in reference to sodium chloride, is used in the formulation of processed meat products to increase water holding capacity, solubilize myofibrillar protein to improve product texture, and as a flavoring. When included in product formulations at levels in excess of 3% of weight, salt acts as a preservative by inhibiting microbial growth. Commodity processed meat products typically contain salt at levels less than 3% salt by weight, and in such scenarios salt has a pro-oxidant effect (Jin, Zhang, Yu, Lei, & Wang, 2011), accelerating oxidation of lipids (Overholt et al., 2016; Ruiz, 2007, chap. 7) and pigments (Devatkal & Naveena, 2010; Overholt et al., 2016). In addition to sodium chloride, food grade salts typically contain impurities, often in the form of transition metals, such as iron and copper; both of which have pro-oxidant effects in meat systems (Ladikos & Lougovois, 1990; St. Angelo, Vercellotti, Jacks, & Legendre, 1996).

Recent estimates project the global sales of "gourmet" or "specialty" salts to exceed $1.34 billion by 2019 (Markets and Markets, 2014). Consumer demands for "natural" products are likely to increase the demand for the use of such "gourmet" or "specialty" salts in meat products. However, "gourmet" salts have greater concentrations of impurities, including known pro-oxidants, than refined salts typically used in meat processing (Bess et al., 2013; Overholt et al., 2016). Thus, the use of such salts presents potential challenges in controlling lipid oxidation and color stability in processed meat products.

Specialty or "gourmet" salts included in ground pork patties elicited varying rates of lipid oxidation and color stability; however, the differences in lipid oxidation did not result in differences in oxidized flavor or odor (Overholt et al., 2016). Additionally, "specialty" salts less effectively solubilized myofibrillar proteins (Bess et al., 2013; Overholt et al., 2016). Even so, it is not known what effect the use of less pure, "specialty" or "gourmet" salts may have on processing yields of injected meat products. Further research is needed to determine the effects of "gourmet" salts on color stability of whole muscle, further processed meat. Therefore, objectives of the study were to determine the effects of an industry-typical (**Control**) and 3 "gourmet" (**Grey** sea, **Pink** rock, and unrefined **Rock**) salts on the processing yields and shelf-life of moisture-enhanced pork loins.

2. Materials and methods

2.1. Raw materials

Salts used included a salt typically used in meat processing (Top-Flo granulated salt, Cargill Salt, Minneapolis, MN), and three commonly available "gourmet" salts. The "gourmet" salts were a Grey sea salt

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Table 1
Mineral composition of salts.

Mineral	Control	Grey	Pink	Rock
Sodium, g/100 g	40.2	38.50	39.70	39.90
Chloride, g/100 g	59.8	57.90	58.12	58.90
Iron, mg/kg	248	153	219	177
Copper, mg/kg	14.0	5.0	4.9	1.1
Magnesium, mg/kg	30	3740	1740	220
Calcium, mg/kg	< 0.6	2030	2380	1760
Manganese, mg/kg	6.2	3.8	4.9	9.5

(French Grey Gourmet Sea Salt, San Francisco Salt Co., San Leandor, CA), a Himalayan Pink rock salt (Sherpa Pink Himalayan Gourmet Salt, San Francisco Salt Co., San Leandro, CA), and a common Rock salt (Real Salt, Redmond Trading Co. L.C., Heber City, UT). All four salts were procured from commercial vendors. These salts were selected because of their use in "gourmet" cooking and their perceived differences in mineral composition. Salts were analyzed for metals known to have a prooxidant effect, as well as Na^+ and Cl^- ions (Table 1), using inductively coupled plamsa-optical spectroscopy (ICP-OES; method 9851.01; AOAC Int., 2007).

A total of 164 Canadian back loins (NAMP #414; North American Meat Institute, 2014) were procured from pigs raised in a feeding trial comparing the efficacy among a direct fed anti-microbial, a direct fed antibiotic, and feeding no anti-microbial or antibiotic (control). Loin weight, pH, and instrumental color were evaluated at approximately 1 d postmortem. Statistical comparisons were made among the three feeding treatments to determine if any differences in loin quality existed among treatments. There were no statistical differences in quality traits (Lowell et al., 2018), therefore loins used in the present study were selected from all three feeding treatments. At 1 d postmortem, boneless loins were bisected with a cut between the 10th and 11th ribs. From the posterior section (consisting solely of the *longissimus dorsi* muscle beginning at the location of the 11th rib), samples representing 8.89 cm of the loin were removed (Lowell et al., 2018). The remaining sections of loin were given identification tags and stored at 4 °C until the next day.

2.2. Formulation and packaging

At 2 d postmortem, pork loin sections were weighed to collect initial weight then blocked by weight and allotted to 1 of 4 salt treatments (n = 41). For each salt treatment, a master batch of enhancement solution was formulated to deliver 3.5% of salt dissolved in water, with no other ingredients. Loins were injected to a targeted solution uptake of 10% of initial weight, resulting in a targeted salt inclusion of 0.32%. Immediately after injection, loins were weighed to collect injected weight and to calculate injection yield; [(Injected weight – Initial weight) ÷ Initial weight] × 100. Injected loins were then allowed to drain for 15 min and weighed again to collect drained weight and to calculate drained yield; [(Drained weight – Initial weight) ÷ Initial weight] × 100.

From each treatment group, 12 loins were randomly selected for simulated retail display. Beginning at the anterior end of each selected loin, two 1.27 cm chops were removed to analyze for initial lipid oxidation (Thiobarbituric Acid Reactive Substances; **TBARS**) and proximate composition. Another 1.27 cm chop and a 2.54 cm thick chop were next removed for simulated retail display, to be used to evaluate end of display TBARS and Warner-Bratzler Shear Force (**WBSF**). Finally, an additional 2.54 cm chop was cut to evaluate 1 d postmortem Warner-Bratzler Shear Force WBSF. Both retail display chops were then weighed to record initial chop weight, placed side-by-side in polystyrene trays with absorbent pads and overwrapped with polyvinylchloride (PVC) film (oxygen transmission rate = 1627.9 cc/m^2/d; moisture vapor transmission rate = 170.5 g/m^2/d). Chops were randomly assigned to 1 of 4 wire mesh shelves, then arranged side-by-side in two single-layer rows resulting in 16 packages per shelf. Two light fixtures with 32W, 122 cm long fluorescent light bulbs (Ecolux with Starcoat, 3000K, General Electric, Boston, MA) were suspended 38 cm above each shelf. Simulated retail display was terminated at the conclusion of 6 d.

2.3. Color evaluation

All evaluations were made through the PVC film each day of simulated retail display using the procedures of Holmer et al. (2009). Visual discoloration scores were assigned based on the appearance of the 2.54 cm chop in each package by a 2-person panel experienced with meat color evaluation using a 10 cm unstructured line scale with each 1 cm increment equal to a 10% discoloration at the surface. Scores from the two panelists were averaged. Instrumental color evaluation (L*, a*, b*, 630/580 ratio) was conducted on the 2.54 cm chop in each package by taking 2 measurements with a Hunter Lab Miniscan XE Plus (Model 45/0-L, Hunter Associates Laboratory Inc., Reston, VA, USA) using illuminant D65, 10° observer, and a 25 mm aperture. The 2 color measurements were averaged. The spectrocolorimeter was calibrated each day against black and white tiles covered with the same PVC film used to package the loin chops.

At the conclusion of retail display, chops were removed from packaging and weighed to calculate storage purge loss; [(Initial chop weight – Final chop weight) ÷ Initial chop weight] × 100. The 1.27 cm and 2. 54 cm chops were individually packaged in a vacuum-sealed bags and frozen at −20 °C until analysis of TBARS and WBSF, respectively.

2.4. Warner-Bratzler shear force

Vacuum-packaged chops were allowed to thaw at 4 °C for 18 h before analysis, trimmed of excess fat, and weighed before being cooked on a Farberware Open Hearth grill (model 455N; Walter Kidde, Bronx, NY). Chops were flipped once at an internal temperature of 35 °C and then cooked until they reached an internal temperature of 70 °C. Internal temperature was monitored using copper-constantan thermocouples (Type T; Omega Engineering, Stamford, CT) connected to a digital scanning thermometer (model 92000-00; Barnant Co., Barrington, IL). Chops were then cooled to 25 °C and weighed. Cooking loss was calculated; [(Pre-cooked weight – Cooked weight) ÷ Pre-cooked weight] × 100. Four 1.27 cm diameter cores were removed from cooled chops parallel to the orientation of the muscle fibers. Cores were then sheared once through the center using a Texture Analyzer TA.HD Plus (Texture Technologies Corp., Scarsdale, NY/Stable Micro Systems Ltd., Godalming, UK) with a blade speed of 3.3 mm/s and a 100-kg load cell. Shear force was reported as the average peak force of the 4 cores.

2.5. Thiobarbituric acid reactive substances

Thiobarbituric acid reactive substances (**TBARS**), moisture, and extractable lipid content were evaluated on samples collected from chops immediately after injection and draining and on the 1.27 cm chop that underwent retail display. Thiobarbituric acid reactive substances were evaluated using a modified version of the procedure described by Leick et al. (2010). Samples were analyzed for malanaldedyde (MDA) content using a 96-well plate in a Synergy HT Multi-Mode Microplate Reader (Bio-Tek, Winooski, VT). A standard concentration curve was plotted with TEP (1,1,3,3- tetraethoxypropane; 0–7.5 mM) to obtain the MDA concentration. From the same ground sample used to analyze TBARS, moisture and extractable lipid content were analyzed using the chloroform:methanol method of Novakofski, Park, Bechtel, and McKeith (1989). Results were expressed as mg MDA/g extractable lipid in order to account for any differences in intramuscular fat between

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