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Influence of sodium chloride reduction and replacement with potassium chloride based salts on the sensory and physico-chemical characteristics of pork sausage patties

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ABSTRACT

This study evaluated the effects of sodium chloride reduction and replacement with potassium chloride or modified potassium chloride based salts using a weight or molar equivalent basis on the sensory and physico-chemical properties of pork sausage patties. Three independent replications of pork sausage patties were manufactured to compare five treatments: full sodium, reduced sodium, modified potassium chloride weight based replacement, modified potassium chloride molar based replacement, and standard potassium chloride weight based replacement. Salt replacement did not affect ($P > 0.05$) moisture, protein, fat, textural properties, lipid oxidation, or redness. Sausage patties with modified potassium chloride were more acceptable than those with standard potassium chloride ($P < 0.001$). Using modified potassium chloride replaced on a molar equivalent basis resulted in samples with more similar sensory characteristics to the full sodium control than replacement on a weight equivalent basis. The use of modified potassium chloride reduced sodium and improved sodium:potassium ratios while other changes in composition or physico-chemical characteristics were minimal.

1. Introduction

Excessive sodium intake has been associated with cardiovascular disease. The United States Department of Agriculture (USDA) and U.S. Department of Health and Human services (HHS) (2010) recommend daily sodium intake to be no > 2300 mg/day. An estimated 77% of daily sodium consumption comes from processed and restaurant foods (Mattes & Donnelly, 1991). Similarly, Anderson et al. (2010) reported 71% of sodium intake in the US is from processed foods but suggest that this likely underestimates the actual amount. Consequently, recent efforts have been made to reduce sodium content in foods and monitoring of commercially processed and restaurant foods has suggested that 43 of 73 sentinel food categories have had > 10% reduction in sodium (Ahuja et al., 2015).

One difficulty in achieving further reduction of sodium is the multitude of sodium containing functional ingredients. Simply removing or reducing these compounds can negatively impact product quality, acceptability and shelf life (Ruusunen & Puolanne, 2005). Sodium chloride is an important multifunctional ingredient in processed meats. In meat processing, sodium chloride is used to extract myofibrillar proteins which is important for product binding and texture (Bombrun, Gatellier, Carlier, & Kondjoyan, 2014; Desmond, 2006). The addition of sodium chloride provides a salty flavor and enhances the other flavors of the product (Aaslyng, Vestergaard, & Koch, 2014; Tobin, O'Sullivan, Hamill, & Kerry, 2012a, 2012b). Through adding sodium chloride to raw meat products, a shift in the microbial population (spoilage and pathogenic bacteria) and delay in the rate of growth of these organisms occur (Blickstad & Molin, 1983; Madril & Sofos, 1985; Whiting, Benedict, Kunsch, & Woychik, 1984). The addition of sodium chloride improves moisture retention in raw meat and during cooking (Horita, Messias, Morgano, Hayakawa, & Pollonio, 2014; Tobin et al., 2012a, 2012b; Xiong, Noel, & Moody, 1999). Due to these functions, reducing sodium is not as simple as just reducing the amount of sodium chloride added. Therefore much work has been conducted to identify ingredients and processing technologies to replace the functionality of sodium chloride.

Potassium chloride provides one of the most direct substitutions due to the similarity in molecular composition but its use can be limited due to negative sensory attributes. The chloride anion is responsible for myofibrillar protein extraction which helps with increased bind and emulsion stability. Protein extraction can be maintained with a 50% replacement of sodium chloride with potassium but this substitution amount also leads to reduced sensory attributes and overall acceptance by consumers (Horita et al., 2014). To achieve a similar perception of

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saltiness, 33% more potassium chloride than sodium chloride is required in an aqueous solution (Feltrin, de Souza, Saraiva, Nunes, & Pinheiro, 2015). Substituting sodium chloride with potassium chloride on a molar basis provides similar antimicrobial effectiveness against several pathogens: *A. hydrophila*, *E. sakazakii*, *S. Flexneri*, *Y. enterocolitica*, and three strains of *S. aureus* (Bidlas & Lambert, 2008).

Even with the efforts to reduce sodium content of processed foods, use of potassium chloride has been limited due to bitterness and off-flavors that can be associated with its use. A patented process to produce a potassium chloride based crystal (Chigurupati, 2011) has been developed with the potential to more closely mimic sodium flavor and reduce negative sensory attributes associated with using potassium chloride salts. In the modification process, the potassium chloride is treated with citric acid and mixed with a maltodextrin carrier before being spray dried. One study investigated this modified potassium chloride based salt and summarized that sodium chloride could be partially replaced with the modified potassium chloride without negatively impacting protein extraction, yield, or texture of cooked sausages (Zhao & Claus, 2013). The previous study, like most others, has investigated substitution of sodium chloride with potassium chloride on a weight equivalent basis. The objective of this study was to evaluate sodium chloride reduction and replacement with potassium chloride based salts on a weight or molar basis on the sensory and physicochemical and sensory properties of pork sausage patties.

2. Materials and methods

2.1. Materials and treatments

Boneless pork shoulder butts, USDA (2014) IMPS# 406A, were purchased from a regional distributor and stored frozen until product manufacture. All non-meat ingredients were provided by NuTek Food Science LLC (Minnetonka, MN). All products were formulated (Table 1) to contain 94.79% boneless pork shoulder butts, 1.14% breakfast sausage seasoning (BFSTK-BREAKTRAD-no salt, International Spices, Fremont, NE), and 0.02% rosemary oleoresin (5XT-W Herbalox Brand Rosemary Oleoresin Kalsec Inc. Kalamazoo, MI). Modified potassium chloride based salt (NTS; NuTek Salt 15,000, NuTek Food Science, LLC, Minnetonka, MN) contains 85% potassium chloride. The amount of sodium chloride and potassium chloride salts varied between treatment and water was adjusted to maintain equal batch weights. On a raw meat basis, all reduced sodium treatments contained 37.05% less sodium chloride. Treatments included: Control = sodium chloride (1.7%) control; Reduced sodium negative control (RS Control) = reduced sodium chloride (1.07%); NTS 1.2 = reduced sodium chloride (1.07%) with NTS (0.75%), weight replacement basis; NTS 1.5 = reduced sodium chloride (1.07%) with NTS (0.94%), molar replacement basis; KCl 1.0 = reduced sodium chloride (1.07%) with potassium chloride (0.63%). As the NTS 15000 modified potassium chloride contains 85% potassium chloride, the NTS 1.2 treatment represents sodium chloride being replaced with potassium chloride on a weight equivalent basis whereas NTS 1.5 represents sodium chloride being replaced on a molar equivalent basis.

2.2. Product manufacture and handling

Three independent replications were manufactured on separate days. For each replication, pork was allowed to temper at 1–2 °C for three days prior to manufacture. Boneless pork shoulder butts were course ground through a plate with 9.25 mm holes (4734, Hobart Manufacturing Co., Troy, OH). All meat (21.55 kg) and non-meat ingredients and 5% dry ice were added and mixed in a dual action mixer (100DA70, Leland Southwest, Fort Worth, TX) for 90 s. As the control treatment was used for sensory panel evaluations, two 21.55 kg batches were mixed for the control per replication to ensure sufficient quantity of patties. After mixing, the two control mixing batches were commingled during grinding. The sausage mixture was reground through a plate with 4.76 mm holes. A patty maker (Protégé, Patty-O-Matic, Farmingdale, NJ) was used to from 76 g patties that were 9.25 mm thick and 98 mm in diameter. Patties were placed on Styrofoam trays and overwrapped in oxygen permeable polyvinyl chloride film to be placed in simulated retail display. Patties were removed from retail display and vacuum packaged on the appropriate day of sampling and were stored frozen (−80 °C) until analysis for lipid oxidation. All remaining patties were stacked, crust frozen, and placed in a 1.5 mil polyethylene bag lined box and were kept in frozen storage (−20 °C) until evaluation. For evaluations that were conducted on cooked samples, patties were tempered for 24 h in a 1–2 °C cooler and cooked on a 190 °C gas heated flat top griddle (HG4, Hobart Corp., Troy, OH). Patties were cooked for 2.5 min on one side, turned, and cooked for 2.5 min on the other side. Internal temperature was measured at the end of cooking with a T-type thermocouple and product temperature ranged from 73.9 °C to 79.4 °C.

2.3. Proximate composition, sodium, potassium, and pH analysis

Proximate composition, sodium and potassium content, and pH were evaluated on both raw and cooked sausage patties. Moisture and ash content were measured using a LECO thermogravimetric analyzer (TGA 701, LECO Corporation, St. Joseph, MI). Total fat was determined as outlined by the AOAC method 960.39 (AOAC, 1990b) using the Soxhlet extraction procedure. Protein was measured using a LECO

Table 1
Pork sausage formulations.

Treatment[1]	Boneless pork shoulder butts	Water	Spice blend[2]	Salt (sodium chloride)	Modified potassium chloride based salt (ModKCl)[3]	Standard potassium chloride (StdKCl)	Rosemary oleoresin[4]
Control	94.79%	2.35%	1.14%	1.70%	0.00%	0.00%	0.02%
RS control	94.79%	2.98%	1.14%	1.07%	0.00%	0.00%	0.02%
NTS 1.2 (1 sodium chloride:1.2 ModKCl wt:wt salt replacement)	94.79%	2.23%	1.14%	1.07%	0.75%	0.00%	0.02%
NTS 1.5 (1 sodium chloride: 1.5 ModKCl wt:wt salt replacement)	94.79%	2.04%	1.14%	1.07%	0.94%	0.00%	0.02%
KCl 1.0 (1 salt: 1 StdKCl: 1 sodium chloride wt:wt salt replacement)	94.79%	2.35%	1.14%	1.07%	0.00%	0.63%	0.02%

[1]Control = full sodium control; RS control = 37.05% reduced sodium negative chloride control; NTS 1.2 = 37.05% reduced sodium chloride with 1:1.2 (wt:wt) sodium chloride:modified potassium chloride based salt (ModKCl) replacement ratio; NTS 1.5 = 37.05% reduced sodium chloride with 1:1.5 (wt:wt) sodium chloride:modified potassium chloride based salt (ModKCl) replacement ratio; KCl 1.0 = 37.05% reduced sodium chloride with 1:1 (wt:wt) sodium chloride:Standard potassium chloride (StdKCl) replacement ratio.
[2]Spice Blend (BFSTK-BREAKTRAD-no salt, International Spices, Fremont, NE).
[3]NuTek Salt 15,000 contains 85% potassium chloride; NuTek Food Science, LLC, Minnetonka, MN.
[4]XT-W Herbalox Brand Rosemary Oleoresin (Kalsec Inc. Kalamazoo, MI).