PE9.35 Reducing sodium levels by up to 58% in cooked cured ham by addition of potassium lactate
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Abstract—Excessive sodium intake is associated with adverse health effects including high blood pressure, development of hypertension, and risk of coronary heart disease and even mortality. Processed meat is a significant source of sodium owing to the use levels of sodium chloride to achieve the desired technical and sensory properties of these products. The effect of adding/increasing potassium lactate (PL) and reducing sodium chloride (NaCl) on chemical, physical, microbiological and sensory traits in cooked uncured hams was investigated. Four formulations were evaluated: (i) typical salt and potassium lactate level (control ham) (2.4% NaCl + 0.9% PL); (ii) reduced salt with no added potassium chloride (1.4% NaCl); (iii) reduced salt with typical level of potassium lactate (1.4% NaCl + 0.9% PL); and, (iv) reduced salt with increased level of potassium lactate (1.4% NaCl + 2.1% PL). Results indicated that ham formulated with 1.4% NaCl + 2.1% PL was comparable to the control ham (2.4% NaCl + 0.9% PL) in cooking yield and aw while the lower levels of salt blends had a lower yield and increased aw (and subsequently less control in outgrowth of inoculated Lactobacillus sakei compared with hams having a higher level salt blend). Furthermore, hams formulated with 2.4% NaCl + 0.9% PL and 1.4% NaCl + 2.1% PL had a better salt flavor and less of a sweet flavor compared with hams formulated with 1.4% NaCl + 0.9% PL and 1.4% NaCl. In general, the reduced-sodium ham formulated with 1.4% NaCl + 2.1% PL had comparable chemical, physical, microbiological and sensory characteristics to the control ham formulated with 2.4% NaCl and 0.9% PL. thus, potassium lactate can be used to reduce the sodium level in cooked cured ham by up to 58%.

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Index Terms—RTE meat, cured ham, Lactobacillus sake, salt reduction, potassium lactate, sodium levels

I. INTRODUCTION

SODIUM intake in industrialized countries exceeds nutritional recommendations by almost 60% and the role of sodium in the prevalence of high blood pressure, development of hypertension, and its positive association with mortality and risk of coronary heart disease has prompted public health officials and regulatory authorities to recommend reduced dietary intake of sodium chloride (since it is the main source of dietary sodium) [6,8]. However, sodium chloride (NaCl) is an essential ingredient in the production of processed meats due to its many benefits including improved emulsification, enhancement of the meat flavor, improved color, improved water-holding capacity and fat-binding (leading to acceptable yield and texture), and lowering of aw to help control microbial growth [3,6].

Meat processors have steadily attempted to manufacture and market reduced-salt alternatives without drastically affecting the acceptability of the products. There are a number of strategies employed for reducing sodium content in ready-to-eat (RTE) meats including (i) simply reducing the level of NaCl added; (ii) replacing all or part of the NaCl with other chloride salts (e.g., potassium chloride (KCl), etc.); (iii) replacing part of the NaCl content with other salts (phosphates, citrates, etc.); (iv) implementation of other processing techniques such as high hydrostatic pressure; and, (v) combinations of the above [1,5,7]. Development of reduced-sodium in processed meats is, however, not a simple process given the important role NaCl plays in protein functionality. The effect of NaCl on meat matrix proteins is complex and modifications in meat formulation become intricate with the addition and interaction of other salts especially the effects on perceived saltiness and intensity of the characteristic meat taste [4]. Typical retail cured processed hams have a NaCl level of ≥2% and a common strategy for sodium reduction is replacement with KCl from 15 to

50% (by ionic basis) without significant deterioration in sensory and physical traits [2,3,4]. Furthermore, use of KCl in combination with NaCl is beneficial since it is a counter-ion to sodium and reduces the harmful effects of sodium on blood pressure [4]. Given this information, the authors hypothesize that use of a potassium salt, in the form of potassium lactate, could be used to reduce the sodium content of cooked cured ham without deterioration of product quality.

The objective of this research was to evaluate the opportunity to reduce sodium levels in cooked cured ham by addition of potassium lactate in the formulation without negatively impacting chemical, physical, microbiological and sensory characteristics.

II. MATERIALS AND METHODS

PREPARATION OF COOKED CURED HAMS

A. Selection of ham recipe

A retail survey was conducted in which various commercial hams were purchased and analyzed for aw, pH, chloride levels as NaCl, moisture, sodium content, and lactic acid content. Based on the results of the above-mentioned analyses, the ham recipe for the investigation was developed to be representative of retail hams.

B. Preparation and treatment of cooked cured hams

The model ham formulation (control ham) consisted of pork topside (69.440% w/w), water (24.560%), sodium chloride (2.400%), sodium triphosphate (0.300%), sodium nitrite (0.006%), dextrose (1.500%), sodium ascorbate (0.050%), sodium glutamate (0.200%), smoke arome (0.040%), and potassium lactate (PL) (0.900%). The model formulation was modified to produce three formulation batches (treatments): (i) reduced salt with no added potassium chloride (1.4% NaCl); (ii) reduced salt with typical level of potassium lactate (1.4% NaCl + 0.9% PL) (PURASAL HiPure P/Plus, PURAC, Inc., Lincolnshire, IL); and, (iii) reduced salt with increased level of potassium lactate (1.4% NaCl + 2.1% PL). The pork topside was stored for 24 h at 0ºC before use. On the day of production, the brines were prepared and the pork topside was injected (44%). A portion (6% of total meat) was ground (to aid in structuring) while the remainder was cut into 5x5cm portions. The brine/meat blends were subsequently placed in vacuum bags with partial vacuum (to avoid foam formation) (Turbovac, HFE Vacuum Systems, 's-Hertogenbosch, the Netherlands) and tumbled (five 30-min cycles with 3 h rest periods between) (LU25, Lumar Ideal, Inc., Montreal, Canada) at 4ºC (batches were tumbled in vacuum bags since all treatments had to tumbled together for sake of time). The tumbled meat was vacuum-packaged in cook crimp bags and inserted into a ham can (2L, Type Ch. 3) under pressure and cooked in a water bath set to 80ºC to an internal temperature of 72ºC. Hams were subsequently cooled in 13ºC water for 45 min before being stored at 0ºC for 24 h. After cooling, hams were removed from the ham can for further analysis (slices of 1.5 mm thickness were prepared for microbiological and sensory analyses).

MEASUREMENT OF CHEMICAL AND PHYSICAL CHARACTERISTICS

A. Chemical measurements

Determination of cooking yields (%) of cooked cured hams from different batches was based on product weight before and after cooking and chilling. The pH of the samples was measured by placing approximately 25 g of sample in a sterile filter bag (M-Tech) and homogenizing (Stomacher 400 Lab Blender, Seward Medical, London, England) with distilled water (1:10) and immersing a pH electrode (744 pH, Metrohm, Herisau, Switzerland) in the bag containing the homogenate. The water activity of the cooked cured hams was determined using an Aw Sprint TH 500 (Novasina, Talstrasse, Switzerland) by placing approximately 5-g portions of chopped meat into a plastic sample cup and inserted into the vapor chamber. Moisture/loss on drying (LOD) was determined within 24 h of production using an oven method (16h at 80ºC).

B. Physical observations

Additional observations were made on product following freezing, and slicing. Cooked cured hams are often frozen (-4ºC) before slicing to aid in sliceability, however, since reduced salt levels increase the freezing point, it was essential to evaluate the effect of freezing on the product quality.

MEASUREMENT OF MICROBIOLOGICAL CHARACTERISTICS

A. Preparation of inocula

Lactobacillus sakei strain 308 (meat isolate, internal collection) was activated individually in deMan Rogosa Sharpe (MRS) broth (Difco, Becton Dickinson, Sparks, MD) (24 h at 30ºC) from frozen stock cultures. Activated cultures were transferred again into MRS broth and incubated for 24 h at 30ºC. An aliquot of the overnight culture was diluted to yield a target level of approximately 2 log CFU/g of final product per package.

B. Product inoculation

Slices (n=2) from each batch of cooked cured hams were placed in individual filter bags (Stomacher bag with lateral filter, M-Tech Diagnostics, Ltd., Cheshire,

UK), surface inoculated with approximately 2 log CFU/g of L. sakei, vacuum-packaged and stored at 4ºC for up to 25 d.

C. Microbiological analyses

Duplicate samples of each treatment were analyzed on days 0, 4, 7, 15, 20, and 25 on MRS agar (Difco) for L. sakei populations. Each sample (slice) was opened and sterile diluent (8.5% w/w sodium chloride and 0.1% w/v bacteriological peptone) added in a ratio of 1:3 (meat:diluent) and homogenized for 60 s (Stomacher 400 Lab Blender, Seward Medical, London, England). Additional dilutions were also made in the same sterile diluent. A 50 µl portion of the appropriate dilution for each sample was plated (onto MRS agar) using a spiral plater (Eddyjet type 1.23, IUL Instruments, Barcelona, Spain). Plates were incubated for 48 h at 30ºC and the colonies counted using an automatic colony counter (Colyte Supercount, Synoptics, Cambridge, UK) and the associated software package.

D. Statistical analysis

The experiment was conducted twice, and for each replicate two individual samples were analyzed on each sampling day for each treatment (n=4). The microbiological data were converted to log CFU/g based on the sample weight analyzed and the volume of diluent added to each sample. Data for changes in populations of L. sakei were analyzed by one-way analysis of variance to determine significant differences among treatments at each weekly sampling interval using Minitab version 14.2 statistical software (Minitab, Inc., State College, PA). Differences were considered significant when the associated P value was less than 0.05.

MEASUREMENT OF SENSORY CHARACTERISTICS

A. Sensory evaluation

Sensory analysis was performed to evaluate the effect of treatments on the sensory properties of cooked cured hams formulated with different NaCl and PL levels. Sensory was performed on sliced samples from each treatment. Samples were blinded with a random three-digit number. A trained panel of seven consumers from the Application Centre, Meat (PURAC Biochem b.v., Gorinchem, the Netherlands) was used to evaluate sliced cooked cured hams for salt, sweet, sour, bitter, and meat taste using a 5-point hedonic scale (0 = not detected; 5 = strong taste). Means and standard deviations of the scores for each attribute were calculated.

III. RESULTS AND DISCUSSION

The goal of this study was to evaluate the effect of reduced salt levels in cooked cured hams by addition of potassium lactate. For this purpose, a control ham containing 2.4% NaCl and 0.9% PL (typical level of these ingredients in retail hams determined by analysis [data not shown]) was compared to hams with a reduced salt level of 1.4% and no lactate, typical lactate level (0.9% PL), and an increased lactate level (2.1% PL). It was important that hams formulated as described above be analyzed for chemical/physical, microbiological, and sensory characteristics that would determine the feasibility of reducing NaCl by adding PL. Results from the yield measurements had the following trend 2.4% NaCl + 0.9% PL = 1.4% NaCl + 2.1% PL > 1.4% NaCl + 0.9% PL > 1.4% NaCl (Table 1). This suggests that the ham with reduced salt and increased lactate level was as effective in maintaining the water-binding capacity compared to the control ham with a higher salt level. The results for aw followed a similar trend 2.4% NaCl + 0.9% PL = 1.4% NaCl + 2.1% PL > 1.4% NaCl + 0.9% PL > 1.4% NaCl (Table 1). One of the functions of NaCl in processed meats is to decrease the water activity and thereby control microbial growth and indeed the outgrowth of L. sakei on ham was correlated with aw of the product as a result of the addition of PL (Figure 1). Levels of L. sakei did not differ ($P \geq 0.05$) at day 0 or 4, however, control of growth after day-4 decreased as follows 2.4% NaCl + 0.9% PL = 1.4% NaCl + 2.1% PL = 1.4% NaCl + 0.9% PL > 1.4% NaCl (Figure 1). Although many other salt replacers have a favorable outcome on taste they do not contribute positively to maintenance of product shelf-life. The effect of freezing the cooked cured hams was dramatic. Hams formulated with 2.4% NaCl + 0.9% PL and 1.4% NaCl + 2.1% PL had no ice crystal formation compared with the hams formulated with 1.4% NaCl and 1.4% NaCl + 0.9% PL (data not shown). Following freezing, hams formulated with 1.4% NaCl and 1.4% NaCl + 0.9% PL also displayed a pitted appearance relative to the smooth, well-structured appearance of hams formulated with 2.4% NaCl + 0.9% PL and 1.4% NaCl + 2.1% PL, the latter two formulations also had better sliceability (better firmness). The sensory criteria with the largest spread in panelist response were salt and sweet taste (Figure 2). Hams formulated with 2.4% NaCl + 0.9% PL and 1.4% NaCl + 2.1% PL had a higher perceived salt taste and a lower sweet taste compared to the hams formulated with 1.4% NaCl and 1.4% NaCl + 0.9% PL. Interestingly, reduced salt (1.4%) formulations with and without added PL had a slightly higher characteristic meat taste than ham formulated with 2.4% NaCl and 0.9% PL (Figure 2).

IV. CONCLUSION

Potassium lactate can be used to effectively reduce the sodium content of cooked cured hams by 58% without adversely affecting the chemical, physical, microbiological, and sensory characteristics of hams with a higher salt level. Meat processors can use these results in reformulating their products to approach the Food Standards Agency (FSA) target of reducing

sodium content of foods (1% Na in cured hams) while still achieving the desired sensory and quality traits of a higher sodium chloride formulation.

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