Meat Science 116 (2016) 102–109

Contents lists available at ScienceDirect

Meat Science

journal homepage: www.elsevier.com/locate/meatsci

The use of high pressure processing to enhance the quality and shelf life of reduced sodium naturally cured restructured cooked hams

Z. Pietrasik *, N.J. Gaudette, S.P. Johnston

Food Processing Development Centre, Food and Bio Processing Division, Alberta Agriculture and Forestry, Leduc, AB T9E 7C5, Canada

ARTICLE INFO

Article history:
Received 1 December 2015
Received in revised form 25 January 2016
Accepted 3 February 2016
Available online 4 February 2016

Keywords:
Salt replacer
Modified potassium chloride
Celery powder
HPP
Nitrite
Natural
Ham
Shelf life

ABSTRACT

The combined effect of partial salt replacement with modified potassium chloride and high pressure processing (600 MPa for 3 min at 8 °C) on the quality and shelf life of naturally-cured restructured hams was investigated over a 12 week storage period. Instrumental, microbiological and consumer acceptability testing was performed. A partial salt substitution with modified potassium chloride adversely affected textural and water binding characteristics of hams and led to a decrease in the consumer acceptance compared to regular salt hams. Celery powder used as a curing agent had beneficial effects on water holding and moisture retention and improved bind of restructured hams; however the consumer acceptability of flavor and aftertaste received significantly lower scores compared to nitrite. No significant differences in all consumer acceptability parameters resulted for hams subjected to HPP compared to non-HPP for all storage periods indicating that HPP can effectively extend shelf-life of restructured ham without compromising eating quality.

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1. Introduction

Consumer demand for reduced sodium foods coupled with an increased consumer concern about chemical additives in conventionally processed foods (Sebranek & Bacus, 2007) has led to increased consumer interests for natural and health orientated processed meat products. The meat industry has addressed these consumer trends through the development of reduced salt, natural (nitrite-free) meat products. A variety of approaches to reduce sodium content of meat products have been reported. These include reducing the level of NaCl added, substituting NaCl with other chloride salts or other binding agents, and altering processing techniques (Desmond, 2006; Ruusunen & Puolanne, 2005).

The Health Check™ Program in Canada provides a target sodium level for the production of reduced sodium foods. Reformulation of meat products to meet reduced sodium targets in conjunction with alternative curing agents (e.g., cultured celery powder or non-converted celery juice powder) can have serious implications for the functional and sensory qualities of processed meat products, as well as their safety and shelf-life. The addition of salt not only enhances the flavor of meat products but also affects functional characteristics such as water-holding capacity, product binding, product texture, and bacterial growth. Meat products made without added nitrite may also be susceptible to safety issues as well as the development of negative sensory attributes (Myers, Montoya, Cannon, Dickson & Sebranek, 2013; Sebranek, Jackson-Davis, Myers, & Lavieri, 2012; Sindelar, Cordray, Sebranek, Love, & Ahn, 2007).

To counteract the functional and food safety concerns introduced by the reformulation required to develop naturally cured meat products with reduced sodium levels, high pressure processing (HPP) can be applied (Han et al., 2011; Jofré, Aymerich, Grebol, & Garriga, 2009; Myers, Montoya, et al., 2013; Oliveira et al., 2015). HPP technology may be a viable process that partially compensates for the reduction of salt levels in processed meat products and will also create additional assurances in regard to food safety and shelf life to reduced sodium products that contain alternative sources of curing ingredients.

The objective of this study was to determine the effects of nitrite source and partial substitution of sodium chloride with modified potassium chloride on functionality, quality, shelf life and consumer acceptability of restructured ham subjected to post-packaging high pressure treatment.

2. Materials and methods

2.1. Materials and ham processing

For each of three replications, boneless, skinless pork inside rounds (*semimembranosus* and *adductor* muscles) were purchased from a

* Corresponding author at: Food and Bio Processing Division, Alberta Agriculture and Forestry, 6309-45 Street, Leduc, AB T9E 7C5, Canada.
E-mail address: zeb.pietrasik@gov.ab.ca (Z. Pietrasik).

http://dx.doi.org/10.1016/j.meatsci.2016.02.009
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local producer (Maple Leaf Foods, Lethbridge, AB, Canada) and delivered to the Alberta Agriculture and Forestry Food Processing Development Centre (Leduc, AB, Canada) for processing. Muscles were trimmed of all visible fat and connective tissue, then ground in a grinder (K & G Wetter, Model AW114, Mississauga, ON, Canada) through kidney plate orifices.

All processing was carried out in a refrigerated pilot plant (<7 °C) at the Food Processing Development Centre (FPDC), Leduc, AB. Four different ham formulations were processed on the same day at the FPDC: Regular salt (RS–PP) ham and Low-salt (LS–PP) ham containing Prague powder (PP, 6.35% of sodium nitrite) as a curing agent, and Regular salt (RS–CP) ham and Low-salt (LS–CP) ham formulated to contain celery powder (CP, 2% of sodium nitrite) as a curing agent (Natcur C, BSA, Montréal, Québec, Canada). The regular salt treatments were formulated to contain 2.4% NaCl, whereas in the LS hams, 41.6% of sodium chloride (1% of formulated NaCl) was replaced with Low-So Salt Replacer (Nu Tek modified potassium chloride). For each formulation, the brine (equivalent to 30% pump above green weight) also included 2.5% dextrose and 0.5% sugar (Newly Weds Foods Co., Edmonton, AB, Canada).

The ground meat and brine (total batch size of 50 kg) were placed in a Röschermatic tumbler (Röscherwerke GmbH, Bersenbrück, Germany) and then tumbled (10 rpm) under vacuum (−0.9 bar) at 6 °C for 90 min. The meat mixture was then placed into refrigerated, overnight storage. The next day, each treatment batch was stuffed (Handtmann, Model VF80, Waterloo, ON) into presoaked, fibrous casings (105 mm diameter, UniPac, Edmonton, AB) and casings were tensioned and clipped. The chubs were individually weighed and the product was thermally processed in a smokehouse (Maurer & Söhne, Insel Reichenau, Germany) to a final internal temperature of 71 °C, and then cooled in running water for 30 min and stored at 1 °C until use. Following overnight refrigerated storage, each chilled meat chub was removed from its casing and weighed to determine cook yield, calculated as a percentage of raw stuffed weight before cooking. Ten chubs from each formulation were prepared as 3 mm slices that were vacuum packaged (10 slices per package) in high-barrier, mylar/polyethylene pouches (Ulma TF-Supra packaging machine, CyE.S. Coop Ltd., ONATI, Spain) for later use in instrumental and sensory testing. The remaining four chubs from each formulation were vacuum packaged whole.

All vacuum-packaged samples were randomly assigned and divided into two groups: control and HPP. The HPP batches were immediately subjected to high pressure treatment at 600 MPa for 3 min at 8 °C. Then, all samples were randomly allocated to storage interval subgroups (0, 4, 8, 12 weeks), placed into boxes and stored in dark in a walk-in cooler at 2 °C until evaluation.

2.2. Physical characteristic measurement

2.2.1. Proximate analysis and pH

Proximate analysis (total moisture, protein and fat) was conducted using an AOAC-approved (official method 2007.04; Anderson, 2007) near infrared spectrophotometer (FoodScan Lab, Type 78,800, FOSS, Hillerød, Denmark). The pH of cooked products was measured in duplicate with a pH meter (Hanna Instruments FC240, Canadawide Scientific, Ottawa, ON) on a homogenate of 20 g sample in 80 mL deionized water.

2.2.2. Sodium content

Duplicate samples were prepared from each treatment by blending 20 g of sample with 80 g of distilled water for one minute (Magic Bullet blender, Homeland Housewares, USA). The pH of the homogenate was adjusted to pH 9 with a sodium ionic strength adjuster (4 M NH_4Cl & 4 M NH_4OH, Fisher Scientific, Edmonton, AB) and sodium content was measured with an ion-selective combination sodium electrode (pHoenix Electrode Co., Houston, TX) connected to an ion meter (Thermo Fisher Scientific Orion 5-Star pH/ISE/Cond/DO, Beverly, MA), and based on the method described by Averill (1983). Sodium ion concentration ($mg \cdot L^{-1}$) was read directly from the adjusted homogenate.

2.2.3. TBARS analysis

Lipid oxidation was measured by the 2-thiobarbituric acid reactive substances (TBARS) test (Tarladgis, Watts, & Younathan, 1960) with modifications for nitrite interference in cured meats (Zipser & Watts, 1962). Briefly, 10.0 g of sample was combined with 49.0 mL of reverse osmosis (RO) water and 1.0 mL of sulfanilamide reagent (0.5% sulfanilamide in 20% HCl (v/v)) in a Magic Bullet blender and ground for 30 s. The mixture was transferred to a round bottom boiling flask along with 48.0 mL of RO water used to wash the blender. 2.0 mL of 4 N HCl was added to bring the mixture to a pH of 1.5. Glass boiling beads (6) were added to the boiling flask which was then heated to a vigorous boil on a hot plate (Corning PC-620D, Corning Incorporated Life Sciences, Tewksbury, MA) set to 375 °C. A simple glassware distillation apparatus (hotplate, boiling flask, short vertical column connected to a sloped, horizontal water cooled condenser) was used to capture ~50 mL of distillate. 5.0 mL of the distillate was combined with 5.0 mL of TBA reagent (0.02 M 2-thiobarbituric acid in 90% glacial acetic acid) in a 50 mL screw cap glass tube and mixed by vortex (VWR Vortexer 2, VWR International Co., Edmonton, AB) for 10 s at maximum speed. Tubes were then immersed in a boiling water bath for 35 min followed by cooling in tap water for 10 min. The absorbance at 538 nm of the resultant solution was measured by a spectrophotometer (Agilent 8453 UV/Vis Spectrophotometer, Agilent Technologies Canada Inc., Mississauga, ON) against a RO water–TBA reagent blank. TBARS values were determined against a linear standard curve of malonaldehyde standard solution (1,1,3,3-tetra-ethoxypropane). TBARS values were reported as milligram of malonaldehyde equivalents/kilogram of meat sample. For each treatment, measurements were made in duplicate.

2.2.4. Residual nitrite analysis

Residual nitrite was determined by the AOAC method (AOAC, 2000). All residual nitrite assays were done in duplicate.

2.2.5. Total and cured pigment analysis

Mononitrosylhemochrome (cured meat pigment) and total pigment concentrations were measured after extraction in acetone and acidified acetone, respectively (Horsney, 1956). The experiment including sample preparation was done in subdued light to reduce pigment fading. Samples were finely chopped prior to extraction. For optimal extraction of heme pigments an 80:20 ratio of acetone:aqueous components (including sample moisture content) was maintained in all pigment extractions.

Cured pigment analysis was conducted using a modified method of Horsney (1956). Duplicate 2.0 g samples were mixed with 9.0 mL of acetone reagent (spectrophotometric grade acetone, diluted with RO water to 92.5%) using a glass stir rod for 1 min. Samples were held at room temperature for 10 min, then filtered through a Whatman 42 filter paper. Absorbance was measured at 540 nm on the filtrate in a 1 cm quartz cuvette against an 80:20 acetone:water blank. Nitrosylhemochrome concentration was calculated as $A540 \times 290$ and was recorded in parts per million (ppm).

Total pigment analysis was conducted using a modified method of Horsney (1956). Duplicate 2.0 g samples were mixed with 9.0 mL of acidified acetone reagent, (spectrophotometric grade acetone, diluted to 92.5% with 2 parts RO water and 1 part concentrated HCl) using a glass stir rod for 1 min. The samples were held at room temperature for 90 min, then filtered through Whatman 42 filter paper and immediately analyzed. Absorbance was measured at 640 nm on the filtrate in a 1 cm quartz cuvette against an 80: 20 acetone: water blank. Total pigment concentration was calculated as $A640 \times 680$ and was recorded in ppm.

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