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Salt content and minimum acceptable levels in whole-muscle cured meat products

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ABSTRACT

Reported salt levels in whole-muscle cured meat products differ substantially within and among European countries, providing substantial scope for salt reduction across this sector. The objective of this study was to identify the minimum acceptable salt levels in typical whole-muscle cured products in terms of physicochemical, microbial and sensorial properties. Salt levels in a small selection of commercial Irish meat products were determined to establish a baseline for reduction. Subsequently, eight different back bacon rasher and cooked ham products were produced with varying levels of salt: 2.9%, 2.5%, 2% and 1.5% for bacon, and 2%, 1.6%, 1.0% and 0.8% for ham. Salt reduction produced products with significantly harder texture and higher microbial counts, with no difference in the colour and affecting the sensory properties. Nonetheless, salt reduction proved to be feasible to levels of 34% and 19% in bacon and ham products, respectively, compared to baseline.

1. Introduction

Sodium contributes to several important physiological functions in the human body including maintenance of cellular membrane potential and blood pressure. However, there is substantial evidence that excessive sodium consumption is a major contributor to cardiovascular disease, due to its ability to raise blood pressure (Cook, Appel, & Whelton, 2016; Frieden, 2016; He, Pombo-Rodrigues, & MacGregor, 2014; Mozaffarian et al., 2014). In recent years, this evidence has been challenged by different authors and institutions declaring a U or J curve for sodium consumption and risk of disease (Graudal, 2016; IOM, 2013; Mente et al., 2016). Nonetheless, there is a consensus on the high grade evidence for blood pressure reduction being associated with sodium reduction in the hypertensive population.

In most European countries the prevalence of hypertension is above 30% (Kloss, Meyer, Graeve, & Vetter, 2015) and thus vast tranches of the European population would benefit from sodium reduction strategies in the food industry. On the basis of this evidence, the majority of European countries, under the World Health Organisation policies, have adopted strategies for dietary salt reduction towards meeting the recommended intake of 5 g salt/day—as around 90% of the sodium in our diets comes in this form (WHO, 2013). Twelve countries have already reported reductions in population salt intake and 19 have reduced the salt content in different foodstuffs (Trieu et al., 2015).

After the bread and cereals group, the largest source of sodium (salt) in the European diet is processed meat products (Kloss et al., 2015). Average consumption of meat and meat products for the European adult population is around 1.85 g/kg body weight/day, of which 0.58 g/kg body weight/day comes from processed meat and sausages (EFSA, 2015). Whole-muscle cured meat products constitute an important share of the processed meats; with pork ham and bacon being the most consumed products within this group. It is estimated that a European adult consume around 0.19 g/kg body weight/day of pork ham and bacon (EFSA, 2015). In Ireland, one fifth of the daily salt intake comes from cured and processed meats, wherein bacon and ham were the main contributors at 0.925 g/day (Safefood, 2008). Considering the high contribution of these products to the dietary sodium intake, specific salt reduction strategies for these products would have a great impact.

Salt has an important role in meat products as it not only provides the characteristic salty taste and flavour, but it is also essential in the development of the adequate texture—through water binding properties—and acts as preserving agent (Desmond, 2006; Puolanne & Halonen, 2010). Therefore, any reformulation of meat products involving salt reduction should be accompanied by a thorough analysis of their sensory acceptance, physicochemical properties and stability. There has been plenty of work on the effect of salt level on these properties in several meat products (Fellendorf, O'Sullivan, & Kerry,

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2015, 2017; Fougy et al., 2016; Lorenzo, Fonseca, Gómez, & Domínguez, 2015; Purrinos et al., 2011; Ruusunen et al., 2005; Samapundo et al., 2013; Taormina, 2010; Tobin, O'Sullivan, Hamill, & Kerry, 2012a,b, 2013; Ventanas, Puolanne, & Tuorila, 2010) but only a few analysing the three aspects altogether (Aaslyng, Vestergaard, & Koch, 2014; Yotsuyanagi et al., 2016). The primary strategy for salt reduction in meat products has been the use of salt replacers, mainly chloride salts (Armenteros, Aristoy, Barat, & Toldrá, 2012; Desmond, 2006; Fellendorf, O'Sullivan, & Kerry, 2016a,b; Lorenzo, Cittadini, Bermúdez, Munekata, & Domínguez, 2015). However, with the growing interest for clean label products, there is need to ascertain if salt can be reduced without the addition of any replacer. The vast majority of the literature on this field corresponds to comminuted meat products for the reason that the recipe can be tweaked more easily, as in contrast with whole-muscle cured products where the meat and fat content cannot be altered. It is also important to highlight the role of lean meat, as it has been reported that an increased meat protein content reduces the perceived saltiness of the products (Ruusunen et al., 2005).

The aim of this study is to determine the minimum acceptable salt levels in terms of functionality, both sensorial and physicochemical properties, and microbial stability in bacon and cooked ham products.

2. Materials and methods

2.1. Preliminary investigation of levels of salt in commercial products throughout Europe

A review study was conducted on declared salt levels of bacon and cooked ham from six different European countries: Germany, France, Ireland, Italy, Spain and the United Kingdom. In each of these countries, an online search of several retailers was conducted and salt content of different brands and types of the aforementioned products were obtained from their nutritional labels (113 and 223 bacon and ham samples, respectively).

2.2. Survey of levels of salt in Irish cured meat products

In order to get a preliminary indication of the levels of salt in typical commercial products, bacon and ham products were purchased from four different Irish retailers; including three different types of cooked ham products (n = 30): premium, formed and reformed ham (with added and no added water); four types of bacon rashers (n = 23): back and streaky (smoked and unsmoked versions of each), and two types of joints (n = 16): bacon and ham. For each sample the package was opened, fully homogenised in a Robot Coupe (R101, Robot Coupe SA, France) and analysed in triplicate for proximate composition and salt.

2.3. Production of whole-muscle cured meat products

2.3.1. Reduced-salt formulations for back bacon rashers

A study was designed to investigate salt levels in unsmoked back bacon rashers and premium cooked ham that were reduced compared to those observed in the commercial products. The effect of simply reducing the salt content was examined—without addition or substitution using replacers or any extra ingredients, other than water, salt and sodium nitrite—on their sensorial, physicochemical and microbial properties.

Pork loins of eight pigs were purchased from a meat supplier (Ballon Meats, Raheen, Ireland) and transported to the meat processing facility at Teagasc Food Research Centre Ashtown. Four different brines were prepared containing only salt and sodium nitrite (150 ppm). Salt levels were as follows: 2.88% (B2.9-Control), 2.50% (B2.5), 2% (B2) and 1.5% (B1.5). These levels were selected according to the results from the survey as discussed in section 2.2. Each loin was cut in half and was randomly assigned to a different formulation; hence, each formulation was repeated four times. The half-loins were pumped to 113% of their green weight using a 20-needle brine injector (Inject-O-MAT type PSM-21, Dorit Maschinen, Handels AG, Switzerland). The injected loins were weighed, vacuum packed and left to mature at 0–4 °C for 48 h. The bacon was frozen to −5 °C before slicing (3 mm thick) and vacuum packed for future analysis.

2.3.2. Premium cooked ham

Sixteen topside muscles were purchased from an Irish supplier (Rosderra Irish Meats Group, Edenderry, Ireland). The muscles were trimmed of excess fat and stored at 2 ± 2 °C for 24 h. Brines were prepared for 120% injection rate and target levels of 150 ppm sodium nitrite and 2% (H2.0-Control), 1.6%(H1.6), 1.2%(H1.2) and 0.8%(H0.8) salt (NaCl). These levels were selected according to the results from the survey as discussed in section 2.2. Each formulation was repeated four times. Muscles were tumbled (Dorit Vario-Vac VV-T-50, Dorit Food Processing Equipment Ltd., Switzerland) for 6 h at 6 rpm on intervals of 30 min work/rest periods under chilling conditions (2–4 °C). The muscles were then netted, vacuum packed and steam cooked at 85 °C to a core temperature of 72 °C, a chill water shower was applied for 30 min and the hams were then stored for 24 h at 2 ± 1 °C. The hams were weighed throughout the process and cook loss was calculated. The cooked hams were sliced and vacuum packed for subsequent analysis.

2.4. Physicochemical properties

Fat and moisture were determined using the Smart System 5 microwave and NMR Smart Trac rapid Fat Analyser (CEM Corporation USA). Protein concentration was determined using a LECO FP328 (LECO Corp., MI, USA). Salt was calculated from chloride concentration, chloride anions were titrated in ashed (by furnace) samples with silver nitrite using the Mohr method. Colour was analysed using a Ultrascan XE spectrophotometer (CIE L*a*b system); reflectance measurements were also obtained and the cured colour ratio was calculated following the equation: ratio = 650 nm/570 nm (AMSA, 2012). All values were the average of at least triplicates for each of the four batches per formulation. For each batch, four bacon slices were weighted and then cooked on a grill (190 °C) for 2 min on each side. Cooked samples were left at room temperature to cool down and weighted, the cook loss was calculated. Maximum force (N) was assessed on bacon cooked slices using an Instron Universal Testing Machine (Instron Ltd., High Wycombe, UK) with a 10 blade Kramer shear cell. Texture profile analysis (TPA) and expressible moisture were carried out on ham slices (20 mm thick) using the same instrument with a 25 mm circular flat disk and a 500 N load cell, following the methodology as in Resconi et al. (2015). Texture analyses were performed in four samples per formulation and batch.

2.5. Microbial analysis

Vacuum packed slices of bacon and cooked ham were stored in a walk-in cooler at 2 ± 1 °C prior to microbiological analysis (in duplicate of pooled samples) at different time points. The ISO 4833-2:2013 and 15214:1998 were followed for the analysis of total viable counts (TVC) and lactic acid bacteria (LAB), respectively. Water activity was measured in triplicate at room temperature with the Aqualab Lite meter (Decagon Devices Inc., Pullman, WA) following manufacturer's instructions.

2.6. Sensory analysis

The sensory acceptance test was conducted using untrained assessors (n = 24–28) in the age range of 21–65, chosen on the basis that they are consumers of ham and back bacon products (Stone, Bleibaum, & Thomas, 2012). The experiment was conducted in sensory booths at room temperature conforming to the International Standards (ISO,