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The effect of salt reduction on sensory quality and microbial growth in hotdog sausages, bacon, ham and salami

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ABSTRACT

Sodium chloride (NaCl) is a multi-functional ingredient used to inhibit microbial growth and to ensure good texture and taste in processed meat. This study showed how moderately (22–25%) and greatly (43–50%) reduction of NaCl affected yield, sensory quality and microbial growth in hotdog sausages, bacon, cooked cured ham and salami. In greatly reduced products, the yield was reduced by 8% in sausages and 6% in ham, whereas the yield in bacon and salami remained unaffected. The microbial growth was generally not affected by reducing the content of NaCl to 2.0% in sausages, 2.3% in bacon, 1.7% in ham and 6.3% in salami (aqueous phase). Salt taste, juiciness and texture were the sensory parameters most affected by the NaCl reduction. In sausages and ham, reduction from 2.2% to 1.7% and from 2.3% to 1.3% (w/w), respectively, did not alter the sensory properties. In contrast, the sensory properties of bacon and salami were significantly affected already after a moderately reduction.

1. Introduction

Excessive sodium intake is considered to be detrimental to human health (Ezzati, Lopez, Rodgers, Vander, & Murray, 2002; Prospective studies collaboration, 1995), and the majority of the sodium ingested originates from added salt (Brown et al., 2009). It has been calculated that, in the US alone, the potential health benefits of a 3 g/day salt reduction would reduce the number of deaths by 44–92,000 cases and save society in the order of $10–24 billion (Bibbins-Domingo et al., 2010). Likewise, it has been estimated that lowering the amount of ingested salt to 6 g/day would prevent 17,500 deaths per year in the UK (Science Advisory committee on Nutrition, 2003).

It is difficult to quantify precisely the amounts of ingested sodium originating from various food sources, since data in surveys are recorded differently. In some studies, only data for foods for consumption in the home are included, while sodium consumption outside the home (takeaways, restaurants etc.) is not considered (Ni et al., 2010). Differences in cultural eating habits, food pricing, demography, waste patterns for different foods and different degrees of underreporting in surveys further complicate comparison (Ni et al., 2010; Rennie, Coward, & Jebb, 2007).

It has been estimated that approximately 75% of the sodium eaten is added during industrial manufacturing (Brown et al., 2009). The amount added as NaCl by consumers at home varies greatly and has been measured to be anywhere between 11 and 30% (Andersen, Rasmussen, Larsen, & Jakobsen, 2009; Leclercq, Avalle, Ranaldi, Toti, & Ferro-Luzzi, 1990; Sanchez-Castillo, Warrender, Whitehead, & James, 1987). Substantial amounts of salt eaten also originate from fast food and canteen meals (Rasmussen et al., 2010).

Recently, an extensive investigation in the UK calculated the amount of sodium in foods purchased for home consumption. The largest contributors of sodium were processed meats (18%), bread and bakery products (13%), dairy products (12%), and sauces and spreads (11%) (Ni et al., 2010), which is generally in accordance with other studies (Charlton et al., 2005; Webster, Dunford, & Neal, 2010). Hence, contributing approximately one fifth of the total sodium reduction ingested, meat products play an important role with regard to salt reduction.

Political and consumer awareness is increasing. Finland has had a long-lasting national salt reduction programme, and in the past decades much work has also been carried out in the UK (Mohan, Campbell, & Willis, 2009). In recent years, the EU and the US have also given increased attention to salt consumption, and both voluntary and regulatory initiatives have been undertaken to reduce the use of salt (European commission, 2011; New York City government, 2011). The EU has set an annual reduction target of 4% for a 4-year period, although national initiatives will also focus on the reduction of sodium, for example voluntary salt lists with specific targets or different products in the UK and Denmark. However, the meat industry is faced with the problem that salt reduction adversely affects shelf life, food safety, product texture, production yield and taste (Desmond, 2006). For example, salt reduction results in poor texture in emulsified meat products such as frankfurters (McGough, Sato, Rankin, & Sindelar, 2012), reduced salty taste in salami (Zanardi, Ghidini, Conter, & Lanieri, 2010) and in bacon (Jeremiah, Ball, Uttaro, & Gibson, 1996) and in less intensive colour in salami (Zanardi et al., 2010). Nevertheless, it appears that no prior studies have

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systematically documented the simultaneous effect of salt reduction on all of these quality parameters. The majority of scientific studies report on specific problems (e.g. texture and taste), while disregarding the others (e.g. safety, shelf life, yield, taste and consumer acceptance). Furthermore, most investigations are often combined with experiments demonstrating the effect of specific compensatory measures (e.g. ingredients) such as organic acids for shelf life (Zheng, Sebranek, Dickson, Mendonca, & Bailey, 2005), soy sauce for flavour (McGough et al., 2012), seaweed for technological properties (Jimenez-Colmenero et al., 2010) or various other salts such as KCl (Zanardi et al., 2010).

In order for the industry to engage in salt reduction, it is essential that any given product is acceptable with regard to all quality parameters: shelf life, food safety, product texture, production yield, flavour and consumer acceptance, throughout the entire shelf life.

The aim of the present study was to investigate the effect of moderate (approx. 25%) and great (approx. 50%) salt reduction in four major meat products with regard to yield, microbial shelf life, sensory quality and sensory shelf life. The products were chosen to represent the majority of product types produced in the western world: cooked cured whole muscle meat products (ham), emulsion-type sausages (hot dogs), fermented sausages (salami), and cured (non-heated) smoked meats (bacon).

2. Material and methods

2.1. Production, yield and sliceability

Fresh pork was used in all the recipes described below. The meat originated from a commercial Danish slaughterhouse and was from ordinary Danish slaughterpigs. In order to achieve a realistic manufacturing bacterial flora, the bacon and ham were sliced and packed in the production department of a commercial manufacturer. Likewise, the hot dog sausages were also packed in a production environment.

2.1.1. Hotdog Sausages

The hot dog batters consisted of 39% jowls (ESS-FOOD 2032), 31% shoulder (ESS-FOOD 1313), 1% nitrite salt (0.6% $NaNO_2$) (AkzoNobel Salt A/S, Mariager, Denmark), 0.7% spices (Kryta, Roskilde, Denmark), and 0.04% Na-ascorbate (Kryta, Roskilde, Denmark). Different amounts of vacuum salt (AkzoNobel Salt A/S, Mariager, Denmark) were added: 1% (reference), 0.5% (moderately reduced) and 0% (greatly reduced) respectively and ice slurry supplemented up to 100%. The batters were made in a bowl chopper with temperatures starting at 1 °C and ending at 12 °C (+/−1 °C). The batters were then vacuum-stuffed (55 g) in 22 mm lamb casings (Dat-Schaub, Copenhagen, Denmark), smoked and cooked (80 °C). The sausages were packed in PETP/12PEP LLDPE75 bags (Amcor Flexibles, Horsens, Denmark) with 30% CO_2/70% N_2 (AirLiquide, Taastrup, Denmark) (headspace-product 1:1) and stored at 5 °C (+/−0.5 °C) until further analysis.

Three 28 kg batches were produced — one for each salt content. The weight before and after cooking was recorded for the calculation of the cooking yield.

2.1.2. Bacon

Streaky bacon was produced from pork belly (ESS-FOOD 1870) (no rind or ribs) by injecting brine to yield 116%. Three brines were produced with differing salt contents: 7.2% nitrite salt (0.6% $NaNO_2$) (AkzoNobel Salt A/S, Mariager, Denmark) and 0.18% Na-ascorbate (Kryta, Roskilde, Denmark), and different amounts of vacuum salt (AkzoNobel Salt A/S, Mariager, Denmark) were added: 10% (reference), 5.7% (moderately reduced) and 1.4% (greatly reduced) respectively and water supplemented up to 100%. The meat was tumbled for 3 h under vacuum, at 6 rotations per minute (RPM). After 24 h of drainage, the meat was dried at 55 °C for 80 min followed by smoking with wood at 55 °C for 80 min and then cooled. The bacon was sliced (2.8 mm), vacuum-packed and stored at 5 °C (+/− 0.5 °C) until further analysis.

Three 20 kg batches were produced — one for each salt content. The weight of the meat before injection and the amount of product for slicing were recorded for calculation of the processing yield. Likewise, the amount of bacon for slicing into 2.8 mm slices and the amount actually packed were recorded for calculation of the slicing yield.

2.1.3. Cooked cured ham

The pH of the ham muscles was checked in order to exclude material outside the normal Danish pH range of 5.5–5.7. The ham batters consisted of 84% topside ham (ESS-FOOD 1257), 4% shank muscles (ESS-FOOD 2027), 1.0% nitrite salt (0.6% $NaNO_2$)(AkzoNobel Salt A/S, Mariager, Denmark), 0.5% dextrose (Avebe, Veendam, The Netherlands), and 0.05% ascorbate (Kryta, Roskilde, Denmark). Different amounts of vacuum salt (AkzoNobel Salt A/S, Mariager, Denmark) were added: 1.30% salt (reference) 0.74% (moderately reduced) and 0.18% (greatly reduced). Finally, water was added up to 100%. The shank muscles were chopped in a bowl chopper with a proportional part of the brine. The ham muscles were chopped through a kidney plate into pieces measuring 4 × 4 cm. The fine and the coarse parts, together with the remaining brine, were tumbled for 5 min under vacuum. After 20 h of drainage, the meat was tumbled for a further 10 min before being filled (under vacuum) in 100 mm non-permeable casings and was then cooked at 76 °C for 210 min. The meat was then cooled down to 5 °C (+/−0.5 °C) and stored for one week. The hams were sliced (2 mm) and MAP packed in 70% N_2/30% CO_2.

Three 20 kg batches were produced — one for each salt content. The total weight of meat before and after removal of casting and gel separation from the surface was recorded in order to determine the cooking loss and the total amount of product and remains (slicing waste) after slicing was recorded for the calculation of slicing yield.

2.1.4. Salami

Three batters were produced with different salt contents in two replicates, giving a total of six productions. The salami mince consisted of 65% pork shoulder (ESS-FOOD 1313), 31% back fat (ESS-FOOD 2160), 0.6% dextrose (Avebe, Veendam, The Netherlands), 0.4% dried onions (Kryta, Roskilde, Denmark), 0.15% paprika (Kryta, Roskilde, Denmark), 0.05% white pepper (Kryta, Roskilde, Denmark), 0.03% Na-ascorbate (Kryta, Roskilde, Denmark) and 0.03% starter culture (F-1, Chr. Hansen, Hørsholm, Denmark). In addition, vacuum salt (AkzoNobel Salt A/S, Mariager, Denmark) and nitrite salt (AkzoNobel Salt A/S, Mariager, Denmark) were added to ensure 100 ppm nitrite, and 3% NaCl (reference), 2.25% (moderately reduced) and 1.5% (greatly reduced) NaCl in the A, B and C minces, respectively. In minces B and C, an additional amount of shoulder meat was added (up to 100%) in order to compensate for the lower salt addition.

The mince was stuffed (under vacuum) into 60 mm fibre casings and fermented for 50 h at 24 °C. It was then smoked (friction smoke, beech wood) for two hours, fermented for two days at 16–18 °C, then smoked again and finally dried for 20 days, resulting in a total manufacturing time of 25 days and a drying loss of approx. 25%. The pH was checked at 0 h, 17 h, 24 h, 41 h and 48 h, and then daily for an additional four days. The salamis were sliced (1.5 mm) and MAP packed (30% CO_2/70% N_2) and stored at 5 °C (+/−0.5 °C).

The total meat batch weight for each salt content level (12 kg/batch) was recorded before and after fermentation/drying, and the drying loss was calculated. Furthermore, the weight loss was recorded daily for five sausages per batch in order to establish a drying curve. The salamis were sliced into 1.5 mm slices, and the total amount of product and remains after slicing were recorded for calculation of the slicing yield.

2.2. Chemical analysis

For all products, sampling for chemical analysis took place the day after manufacturing.