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Effects of NaCl substitution on the sensory properties of sausages: Temporal aspects

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ABSTRACT

The aim of this study was to determine the effects of different salt substitutes on the sensory perception of sausages. TDS was used to explore the temporal perception of the samples and DA was used as a reference method. Grill-style sausages with different levels of salt reduction combined with different salt substitutes (KCl, Na-lactate, K-lactate/Na-diacetate and milk minerals) were tested. Results showed relatively few discriminating attributes from DA. However, results from TDS indicated differences in the dynamic perception of the sodium reduced sausages compared to the control sample, especially during the aftertaste.

1. Introduction

In many industrialized countries the sodium intake exceeds the nutritional recommendations. A high sodium intake has been linked to health problems, such as hypertension and consequently to an increased risk of cardiovascular diseases (WHO, 2007). NaCl is the main source of sodium in today's human diet, and in European countries more than 70% of the dietary salt intake is estimated to come from processed foods. Especially processed meat products contain relatively high amounts of sodium (Doyle & Glass, 2010; James, Ralph, & Sanchez-Castillo, 1987; Mattes & Donnelly, 1991; Norwegian Directorate of Health, 2010). As sausages are consumed relatively frequent in Norway, a sodium-reduction in such products may represent an important contribution to a general reduction of sodium intake in the population.

Sodium chloride is one of the oldest and most familiar food ingredients (McGough, Sato, Rankin, & Sindelar, 2012). There is no single ingredient that fully can substitute the effect of sodium chloride in foods. Historically, salt has been used for preservation, by lowering water activity to prevent microbial growth. Furthermore, sodium increases the palatability of foods, by contributing to saltiness, enhancing the overall flavor and sometimes suppressing bitterness (Dötsch et al., 2009). Salt is also responsible for the desired textural properties of processed meats as it increases the water holding capacity and the binding properties of proteins. It also increases the viscosity of meat batter and facilitates the incorporation of fat to form heat-stable meat batters (Desmond, 2006; Garcia-Garcia & Totosaus, 2008; Terrell, 1983). Moreover, sodium chloride is a cheap ingredient and the use of any substitute is likely to increase production costs. In addition, a reduction might have economic consequences for the producer due to reduced production yield.

In order to prevent reduction in product quality and profitability for the food industry, a reduction of sodium should be combined with compensatory measures such as the use of salt substitutes and enhancers. Common strategies are replacing parts of the NaCl with chloride salts (e.g. KCl, $CaCl_2$ and $MgCl_2$) or non-chloride salts (e.g. phosphates and lactate salts) either separately or in combination (Ruusunen & Puolanne, 2005).

Among the chloride salts, potassium chloride (KCl) is the most commonly used alternative (Dötsch et al., 2009). KCl contributes to some saltiness by itself, but sometimes imparts off-flavors such as bitterness and metallic flavor (Doyle & Glass, 2010). Previous research has shown that it is possible to replace up to 30–40% of NaCl with KCl in fermented sausages. At higher levels of KCl substitution, a reduction in saltiness and a significant increase of bitterness and hardness have been observed (Gelabert, Gou, Guerrero, & Arnau, 2003; Gou, Guerrero, Gelabert, & Arnau, 1996). Non-chloride salts, such as salts of organic acids, e.g. Na-lactate, K-lactate and Na-diacetate, are other examples of ingredients used for compensating loss of antimicrobial

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effect and loss of flavor in NaCl-reduced meat products (Doyle & Glass, 2010). The antimicrobial effect of lactates can be enhanced synergistically in combination with other organic salts (Devlieghere, Vermeiren, Bontenbal, Lamers, & Debevere, 2009).

Milk minerals, or dairy concentrates, are relatively new types of salt substitutes on the market, and are proposed as salt enhancers applicable for moderate sodium reduction in many different foods (Pszczola, 2007; US Institute of Medicine, 2010). Dairy concentrates are usually fractionated from whey through different isolation techniques. In addition to lactose and calcium, such products naturally contain salts of sodium, potassium, magnesium and calcium phosphate (Walstra, Wouters, & Geurts, 2005). However, the concentration of constituents and the chemical composition of such milk mineral concentrates may vary according to the fractionation process. Though the mechanisms are not fully understood, the observed salt enhancing properties of milk minerals may be attributed to the mineral salts and the flavor enhancing properties may be attributed to the non-protein nitrogen compounds (Minasian, 2011).

There is a growing focus on a healthier diet among consumers in today's society (Desmond, 2006). The development of more palatable sodium-reduced products is important in order to guide consumers towards more healthy food choices. In this context, it is essential to characterize and understand the sensory effects of sodium reduction in foods. Sensory analysis is the most appropriate approach to describe the nature and to quantify the intensity of the sensory properties of food. Descriptive analysis (DA) is the standard methodology for describing the sensory profiles of products. During eating and drinking, upon the influence of mastication and salivation, the sensory properties of foods change (Ng et al., 2012). To take into account the dynamics of perception and the multidimensionality of the perceptual space, the use of a new method called Temporal Dominance of Sensations (TDS) is gaining attention (Pineau et al., 2009). TDS is a descriptive method that enables several attributes to be evaluated simultaneously during consumption of a product. In practice, TDS consists of presenting a panel with a complete list of attributes on a computer screen and asking them to identify, and sometimes to also score the intensity of sensations perceived as "dominant" during consumption of a product. As an outcome, TDS provides a sequence of dominant sensations during a certain time period (e.g. mastication, aftertaste). While two products may have the same average intensities for certain sensory attributes, the sequence in which these attributes are perceived may be different. In addition, with this methodology it is possible to study the interaction between attributes, by recording the evolution of the dominant attributes (Le Reverend, Hidrio, Fernandes, & Aubry, 2008). Upon our knowledge, TDS have not been applied previously to characterize the sensory properties of sodium reduced foods.

The aim of this study was to determine the effects of different salt substitutes on sensory perception of sausages. TDS was used to explore the temporal perception of the samples and DA was used as a sensory reference method. It was of specific interest to learn if the combined information from TDS and DA would provide a more comprehensive overview of the sensory effects of sodium reduction and substitution. Such information may useful for optimization of recipes.

2. Materials and methods

2.1. Samples

Eight sodium reduced sausages and one full sodium sausage (control) were produced by the food manufacturer Stabburet AS at their pilot plant at Råbekken, Norway (Table 1). The control was a grill-style sausage popular in the Norwegian market. The basic recipes contained the following ingredients: meat/fat mix with 25% fat content (43%), nitrate salt (0.8%) phosphate (0.3%), sodium caseinate (1.3%), pork back fat (10.0%), starch (5.7%), glucose (0.3%), sodium ascorbate (0.04%), and spice mix (0.7%). The treatments were a combination of different levels of sodium reduction and different sodium substitutes. Choice of sodium substitutes and levels and range of sodium reduction were determined by the manufacturer based on previous experiences from relevant experiments. Four different reduction levels were used; reduction to 0.7% (sample 1), reduction to 0.6% (sample 2), reduction to 0.5% (samples 3, 4, 6, 7, 8) and reduction to 0.2% (sample 5). Five different sodium substitute strategies were used; KCl (samples 1, 2 and 3), milk minerals (samples 4 and 5), combination of sodium lactate and sodium diacetate (sample 6), combination of K-lactate and Na-diacetate (sample 7) and potassium lactate (sample 8). Water was added according to the recipe of the individual samples (35.86–37.00%).

The sausages were manufactured using a bowl chopper (Kilia 20 liter, Kilia Germany). The meat-fat mixture was mixed with the NaCl (amount depending on sample), nitrite salt, phosphate, ice-water and KCl or milk minerals (depending on the sample), until a temperature of 0 °C was reached. Next, sodium caseinate, ice-water, spices, pork back fat, starch and lactate salt/sodium diacetate (depending on sample), was added to the bowl chopper, and mixed until temperature reached 14 °C. The emulsion was transferred to a vacuum filling machine (Handtmann VF50, Handtmann Germanyfiller) and stuffed into 28 mm cellulose peels (Viscofan 28 mm 55 ft, Viscofan). Sausages were hung on smokehouse sticks, placed on a smokehouse truck and stored overnight at 0–4 °C prior to the cooking and smoking process. Cooking was done in a single truck thermal processing oven (Deutsch cook and smoke cabin, Deutsch Germany) for 90 min in 150 °C until a core temperature of 65 °C. Finally, the sausages were placed in PA/PE 90 μ vacuum pouches (Sacs sous vide, Bokken) and vacuum packaged (Hencovac 1500H, Hencovac, The Netherlands). After cooking and cooling all samples were vacuum-packed separately. Samples were transported to the test location at Nofima (Ås, Norway) for storage at 4 °C.

The samples were heated until a core temperature of 65 °C in an Electrolux Air-o-steam-oven (Combi LW 6 GN 1/1 Gas) at 150 °C and 0% steam. Although the sausages are called "grill-style" this procedure was similar to how such a product normally is heat-treated in commercial settings. After cooking, the samples were cut into pieces of 1.5 $\pm$ 0.1 cm length. Average weight of the samples was 7.9 $\pm$ 0.6 g. For TDS analysis assessors were served one piece of the sample, while for DA assessors were served two adjacent pieces. Samples were served in a white porcelain bowl labeled with a three-digit code and preheated in a hot closet at 60 $\pm$ 1 °C. A lid was placed over the sausage sample to prevent heat loss during the evaluation. Assessors had electrical heating plates (60 $\pm$ 1 °C) available in the sensory booths. Serving temperature of the samples was 52 $\pm$ 2 °C.

2.2. Sensory analysis

Sensory evaluation was conducted on three consecutive days, starting 11 days after the production of the sausages. The sensory analysis was conducted by a trained sensory panel at Nofima. All assessors were selected and trained in accordance with ISO 8586-1 (ISO, 1993) in a sensory laboratory designed in accordance with ISO 8589 (ISO, 2007). Each assessor evaluated all samples using EyeQuestion for direct recording of data (v3.8.7, Logic8, Holland). All samples were expectorated and unsalted crackers and lukewarm water was available for rinsing.

2.2.1. TDS

Trained sensory panelists ($n = 12$) were used for TDS. Panelists were introduced to the notion of temporality of sensations and dominance using the analogy of an orchestra playing music, as proposed by Ng et al. (2012). The dominant sensation was defined as the sensation catching one's attention and it was specified that the dominant sensation is not necessarily the attribute with the highest intensity (Pineau et al., 2009).

For generating a list of dominant attributes, the panelists were instructed to write down all attributes they perceived as dominant