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Fat and salt contents affect the in-mouth temporal sodium release and saltiness perception of chicken sausages

C. Chabanet [a,b,c], A. Tarrega [a,b,c,d], C. Septier [a,b,c], F. Siret [e], C. Salles [a,b,c,*]

[a] INRA, UMR1324 CSGA, 17 rue Sully, F-21000 Dijon, France
[b] CNRS, UMR6265 CSGA, F-21000 Dijon, France
[c] Université de Bourgogne, F-21000 Dijon, France
[d] Laboratorio de Propiedades Físicas y Sensoriales, Instituto de Agroquímica y Tecnología de Alimentos, CSIC. P.O. Box 73, 46100 Burjassot, Spain
[e] CTSCCV (Centre Technique de la Salaison, Charcuterie et Conserve de Viandes) F-94700 Maisons-Alfort, France

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ABSTRACT

In cooked meats, sodium chloride is involved in taste, texture and flavour release. So a reduction in the salt content may have an impact on overall perception and acceptability. The aim of this study was to evaluate the influence of composition on sodium release and saltiness intensity in chicken sausages. The rheological properties of the sausages differed according to composition. Temporal sodium release and temporal saltiness intensity were evaluated by four selected subjects when eating sausages. At each time point, the effect of the salt level in sausages on sodium release was positive and highly significant. The effect of lipids on sodium release was negative. Concerning perception, the amount of salt used had a positive effect on saltiness intensity, and lipids seemed to exert a masking effect. Generally, clear relationships between salt levels, sodium release and saltiness intensity were found but the masking effect of lipids on saltiness intensity probably also involved texture or fat perception mechanisms.

1. Introduction

Sodium chloride is the principal taste compound added to foods. An excessive intake of sodium can cause hypertension and heart disease (Durack, Alonso-Gomez, & Wilkinson, 2008; O'Shaughnessy & Karet, 2004). Nutritional guidelines strongly recommend a significant decrease in the total quantity of dietary sodium chloride. In France, meat products are the second most important vector after bakery products for sodium in the human diet, containing 10% of daily sodium chloride intake (AFSSA, 2002); they are thus particularly concerned by these recommendations. Comparable guidelines have also been issued by the World Health Organization (WHO, 2007). Other sodium salts such as monosodium glutamate, sodium phosphate, sodium citrate and sodium lactate can also be used as food additives in meat product, thus further increasing the sodium content due to salting (Ruusunen & Puolanne, 2005). Meat itself contains a low level of sodium, the majority of which is added during processing. In a complex food matrix such as meat products, sodium chloride is involved in texture, water activity, water and fat holdings, taste and flavour release (Desmond, 2007; Ventanas, Puolanne, & Tuorila, 2010). A reduction in the salt content in foods may therefore have an impact not only on their saltiness intensity but also on their structure and flavour perception, possibly leading to a weaker intensity of the characteristic flavour of products. Several solutions have already been proposed to lower sodium salt and fat levels in different types of sausages. Some are based on the use of fat substitutes (Ayo, Carballo, Solas, & Jimenez-Colmenero, 2008; Youssef & Barbut, 2011) and/or the inclusion of salt substitutes (Beriain, Gomez, Petri, Insausti, & Sarriés, 2011; Campagnol, dos Santos, Morgano, Terra, & Pollonio, 2011; Campagnol, dos Santos, Wagner, Terra, & Pollonio, 2011; Guàrdia, Guerrero, Gelabert, Gou, & Arnau, 2008).

Whatever the solution proposed, it is necessary to understand the effect of such changes to product composition on texture, perception and consumer acceptance, and to gain clear knowledge of the behaviour of flavour stimuli as a function of these composition changes. Sodium chloride brings out the characteristic flavour of foods. Food saltiness intensity is mainly dependent on the sodium chloride concentration, although some other compounds may also include saltiness intensity property (Engel, Nicklaus, Garem, et al., 2000; Engel, Nicklaus, Septier, Salles, & Le Quéré, 2000), or be able to mask or enhance this taste in a food mixture context (Keast & Breslin, 2003). However, perception is a temporal phenomenon dependent on numerous variables such as food composition, mastication and salivary parameters, individual sensitivity and flavour release kinetics. Sodium chloride is released in the mouth when the food matrix is broken down during chewing, and harder foods require more mastication (Jack, Piggott, & Paterson, 1995). Generally, the chewing forces applied, and chewing duration, are affected. Salt release in the mouth

* Corresponding author. Tel.: +33 380 69 30 79; fax: +33 380 69 32 27.
E-mail address: salles@dijon.inra.fr (C. Salles).

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is also dependent on the texture and water content of the food matrix (Davidson, Linforth, Hollowood & Taylor, 2000). When eating food, the temporal perception of saltiness may be related to sodium release parameters. Furthermore, inter-individual differences are very important (Pionnier, Nicklaus, et al., 2004). Temporal sodium release is mainly dependent on water content, while saltiness intensity mainly depends on the fat content of different model cheeses (Phan et al., 2008). Another important oral parameter that is known to influence salt release and perception is the salivary flow-rate. More salt in the saliva raises the salivary pH; mechanical chewing action and sodium chloride release increase the salivary flow-rate (Neyraud, Prinz, & Dransfield, 2003). These authors also reported that the cyclical swallowing and saliva replacement of low-salt saliva was responsible for the cyclical salt concentration in saliva. This is corroborated by previous findings of Pionnier, Chabanet, et al. (2004) and Pionnier, Nicklaus, et al. (2004) who claimed that sodium release was negatively correlated with the salivary flow rate. Moreover, these authors reported that in-mouth taste compounds release patterns were very similar whatever the non-volatile compound, but these release patterns were highly dependent on mastication, salivation and swallowing events.

In meat products, as in many other food products, saltiness intensity has been found to change with composition. Several studies have been carried out on low-fat products but they have produced quite contradictory results. Bologna sausage with a reduced fat content was found to be less salty (Kähkönen & Tuorila, 1998), but with a higher fat content it was more salty (Ruusunen, Simolin, & Puolanne, 2001), whereas another study did not observe any effect of fat content on saltiness intensity relative to the same products, but only reported differences in the duration of saltiness intensity (Ventanas, Puolanne, & Tuorila, 2010). Many physical, structural and physiological factors may therefore be involved in salt release and saltiness intensity. The aim of this study was to evaluate the influence of the principal components of chicken sausages on temporal sodium release and saltiness intensity, in order to determine the extent to which changes in composition might influence saltiness intensity. This study also took account of the oral characteristics of individuals.

2. Materials and methods

2.1. Composition and texture properties of sausages

2.1.1. Materials

Smoked chicken sausages were prepared by Fleury-Michon™ (Pouzauges, France) using chicken meat and fat according to a Box–Behnken experimental design involving three composition factors: fat/protein, water/protein and sodium chloride/protein, with three levels of each. They were of cylindrical form (16 cm length and 1 cm diameter). The design included 13 different compositions with three additional replicates of the central point. Data on composition are shown in Table 1.

Table 1
Composition of the chicken sausages.

Sausage	P	F	W	S	f1 = S/P	f2 = F/P	f3 = W/P
S2F1W1	15.84	15.84	63.35	1.98	0.125	1	4
S1F1W2	14.73	14.73	66.30	1.23	0.083	1	4.5
S3F1W2	14.55	14.55	65.48	2.42	0.167	1	4.5
S2F1W3	13.61	13.61	68.07	1.70	0.125	1	5
S1F2W1	14.20	24.84	56.78	1.18	0.083	1.75	4
S3F2W1	14.02	24.54	56.10	2.34	0.167	1.75	4
S2F2W2[a]	13.15	23.02	59.19	1.64	0.125	1.75	4.5
S1F2W3	12.38	21.67	61.91	1.03	0.083	1.75	5
S3F2W3	12.25	21.44	61.26	2.04	0.167	1.75	5
S2F3W1	12.72	31.80	50.89	1.59	0.125	2.5	4
S1F3W2	12.00	30.00	54.00	1.00	0.083	2.5	4.5
S3F3W2	11.88	29.69	53.45	1.98	0.167	2.5	4.5
S2F3W3	11.25	28.12	56.23	1.41	0.125	2.5	5

P: Protein; F: Lipid; W: Water; S: Salt (NaCl) contents calculated from the experimental design defined by f1, f2, f3 which are the chosen ratio between salt, lipid, or water content and protein content. 1, 2, 3 are low, medium and high concentrations respectively. For all sausage recipes, sugar + ash = 3 g/100 g.

[a] S2F2W2 corresponds to the central point of the experimental design. It was done with three replicates.

2.1.2. Texture

Texture profile analyses were performed on each type of sausage under the experimental design using a TA-XT2 texture analyzer (Swantech International, Gennevilliers France). Each sausage was cut in five equal cylindrical portions (2.5 cm length and 1 cm diameter) and eight sausages of each type was tested (40 samples per type of sausage) in order to minimize sampling effects. Each sample was compressed twice to 30% of its original length between flat plates at a rate of 0.5 mm/s, with 5 s between cycles at room temperature. The following parameters were determined from the texture profile analysis curves obtained as a result of the double compression of sausage portions: hardness (the maximum force required to compress the product), the area under the first curve (A1) (the total energy required for the first compression), the area under the second curve (A2) (the total energy required for the second compression) and cohesiveness (A2/A1).

2.2. Performance of panellists

2.2.1. Masticatory performances

Nine subjects were asked to chew standardised cylinders of a dental silicon polymer Optosil® (Perrigot et Cie, Dijon, France) (Diameter = 1.4 cm, length = 1.8 cm, weight = 3.3 ± 0.05 g). After 20 s, they were asked to spit out the sample into a paper filter and then to rinse their mouths with water. The pieces of chewed sample were then dried in an oven for one hour at 75 °C. The particles were separated using a sieve with a mesh size of 5 mm. The masticatory performance of each subject was defined as the amount of sample that passed through the sieve versus the amount of chewed sample. The procedure was repeated three times in each subject.

2.2.2. Salivation

To determine the salivary flow-rate resulting from mechanical stimulation, two cotton rolls (Roeko, Longenau, Germany) were placed on the aperture duct of the parotid glands and the nine subjects were asked to chew 0.5 ± 0.01 g of Parafilm (American National Can™, Menasha, WI, USA) for a one-minute period without swallowing. The subjects then removed the cotton rolls and spat out the remaining parafilm and saliva into a tare glass. The salivary flow-rate was determined by calculating the weight difference between the cotton rolls and the parafilm portion before the experiment and the sum of spat-out saliva, cotton rolls and parafilm after the experiment. All measurements were performed in triplicate and at the same time of day in all the subjects.

2.2.3. Saltiness sensitivity

This test consisted of scoring saltiness intensity on an unstructured scale for 20 mL sodium chloride solutions (0.25, 0.5, 1, 2 g/L) presented under blinded conditions and in a random order. Pure water and a 2 g/L sodium chloride reference solution (60 mL) were tasted by the subjects and corresponded respectively to the lowest and highest extremities of the assessment scale. The test was performed in triplicate.

2.3. Saliva analysis and salty perception

2.3.1. Selection and training of subjects

Four subjects were selected from the nine for their good sensitivity to saltiness perception, their salivary flow rate (high and low) and their masticatory performance (high and low). Two training sessions