Meta Science 123 (2017) 50–56

Contents lists available at ScienceDirect

Meat Science

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

Impact of lysine and liquid smoke as flavor enhancers on the quality of low-fat Bologna-type sausages with 50% replacement of NaCl by KCl

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ARTICLE INFO

Article history:
Received 1 March 2016
Received in revised form 1 September 2016
Accepted 2 September 2016
Available online 05 September 2016

Keywords:
Low-sodium
Meat products
Flavor enhancers
Sensory properties

ABSTRACT

Low-fat Bologna-type sausages were produced with 50% of NaCl replaced by KCl and with addition of lysine and/or liquid smoke as flavor enhancers. The influence of sodium reduction on technological, physicochemical, and microbiological properties was determined. In addition, the sensory properties were evaluated using a *Check all that apply* questionnaire (CATA) and a consumer study. The partial replacement of NaCl by KCl did not have negative impacts on physicochemical, technological, and microbiological properties. However, the addition of KCl affected the sensory acceptance, as consumers identified by CATA questionnaire a reduction in salty taste and an increase in bitter, astringent, and metallic taste. The isolated or combined addition of lysine and liquid smoke reduced the sensory quality defects caused by the addition of KCl. Therefore, high quality low-fat Bologna-type sausages with sodium reduction close to 50% can be produced by replacing 50% NaCl by KCl and with addition of 1% lysine and/or 0.1% liquid smoke.

1. Introduction

Excessive consumption of fat and sodium is a risk factor for the onset of cardiovascular diseases (He & MacGregor, 2010; Özvural & Vural, 2008), which have increased dramatically in recent years and is currently the leading cause of death in industrialized countries (World Health Organization, 2003; Food Standards Agency, 2009). Based on this, in many countries, public health and regulatory agencies have conducted campaigns to raise awareness about the risks of inadequate diet.

Bologna-type sausages are emulsified meat products that traditionally contain from 20 to 35% fat and 2.2 to 2.5% salt (Feiner, 2006), thus the intake of 100 g of this product provides about 40 to 50% of the daily recommendations for fat and sodium, respectively (WHO, 2003; WHO, 2012). Despite the high amount of fat and sodium, Bologna-type sausages are still widely consumed in countries around the world. For example, in developing countries like Brazil, due to its low price, emulsified meat products are consumed as accompaniments, playing an important nutritional impact on the diet of the population (5 kg/per capita/year) (Olivo & Shimokomaki, 2006). Thus, from a public health perspective, studies on the reduction of fat and sodium in Bologna-type sausages are sorely needed to improve consumers' health.

However, sodium reduction is particularly difficult because it necessarily involves removing or partially replacing NaCl levels, which is the main source of sodium in meat products (Weiss, Gibis, Schuh, & Salminen, 2010). This ingredient gives the characteristic salty taste of meat products and is responsible for the solubilization of myofibrillar proteins. These solubilized proteins are responsible for water retention ability, emulsification and retention of fat in the meat mixture and stability of the gel formed during cooking (Totosaus & Pérez-Chabela, 2009). Moreover, NaCl is an important tool to control microbial growth, thus assisting food safety management (Wirth, 1989).

Several strategies have been used to reduce sodium in meat products. Many studies have reported that the partial replacement of NaCl by KCl is one of the best alternatives to reduce the sodium content in meat products (Campagnol, dos Santos, Morgano, Terra, & Pollonio, 2011a; Campagnol, dos Santos, Wagner, Terra, & Pollonio, 2011b; Dos Santos, Campagnol, Morgano, & Pollonio, 2014; Lorenzo et al., 2015a; Lorenzo, Cittadini, Bermúdez, Munekata, & Dominguez, 2015b. Furthermore, the potassium intake has not been associated with the development of hypertension and cardiovascular diseases (Buemi et al., 2002; Geleijnse et al., 2007; Kimura et al., 2004). However, the technological and sensory quality of the emulsified meat products can be impaired by replacing 50% NaCl by KCl (Horita, Morgano, Celeghini, & Pollonio, 2011). Thus, the search for ingredients that are capable of suppressing defects caused by KCl is configured as a promising approach.

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http://dx.doi.org/10.1016/j.meatsci.2016.09.001
0309-1740/

Given the above, to provide healthy characteristics, Bologna-type sausages were prepared with approximately 50% of fat and sodium found in commercial products. To reduce the fat content, a formulation optimized in previous studies was used (Alves et al., 2016). There are reports that the lysine (Campagnol et al., 2011a; Campagnol, dos Santos, Terra, & Pollonio, 2012) and liquid smoke can reduce the sensory defects caused by high KCl levels (Desmond, 2006; Kilcast & den Ridder, 2007). However, so far there are no reports of use of these ingredients in combination with KCl to reduce the sodium content in emulsified meat products. To reduce the sodium content, a replacement of 50% NaCl by KCl was made, and lysine and liquid smoke were added. Thus, the impact of such reformulation on the technological, physicochemical, microbiological, and sensory properties was assessed.

2. Material and methods

2.1. Treatments

Four low-fat Bologna-type sausages were prepared with partial sodium chloride reduction (50%) followed by substitution with combinations of potassium chloride: KCl (1.25% NaCl, and 1.25% KCl), Lys (1.25% NaCl, 1.25% KCl, and 1% lysine), LS (1.25% NaCl, 1.25% KCl, and 0.1% smoke liquid) and Lys + LS (1.25% NaCl, 1.25% KCl, 1% lysine, and 0.1% liquid smoke). The total content of added salt from these different combinations was kept constant at 2.5%. A control formulation containing 2.5% NaCl was used as a standard for the traditional low-fat Bologna-type sausages. The levels of NaCl, KCl, lysine and smoke liquid and the remaining ingredients, raw materials and additives are described in Table 1. Lysine was provided by the company Ajinomoto Interamericana Indústria e Comércio Ltda (São Paulo, Brasil) and the liquid smoke by the company Fuchs Gewürze do Brasil Ltda (Itupeva, Brasil).

2.2. Manufacture of Bologna-type sausages

Three independent replicates of each batch were prepared in three different days. A total of 10 kg per treatment of Bologna-type sausages were produced in each replicate. To process the Bologna-type sausages, ground pork meat (3 mm, 2 °C), sodium chloride, and sodium tripolyphosphate were placed in the cutter (Model KJ20, Jamar, Brazil) for extraction of myofibrillar proteins. When the temperature of the mixture reached 7 °C, the remaining ingredients, ground pork back-fat (3 mm), and fat replacer were slowly added, followed by comminution until complete homogenization. During comminution, the temperature of the meat mixture did not exceed 10 °C. The mixture was stuffed (Model EJV15, Jamar, Brasil) into water-impermeable plastic casings (Viskase, São Paulo, Brasil) 40 mm in diameter with approximately 0.3 kg of product per package. The Bologna-type sausages were cooked in a water bath according to the following cooking cycle: 60 °C for 30 min, 70 °C for 30 min, and 80 °C until the internal temperature of the product reached 72 °C. A thermocouple was placed in the center of the samples to monitor and control the internal temperature. After cooking, the Bologna-type sausages were immediately cooled in an ice bath. The samples were vacuum-packed in low density barrier pouches (Unipac/Univac B320), using a vacuum sealer (200 Selovac Sealer, Selovac, São Paulo, SP, Brasil) and the samples were stored under refrigeration (4 °C).

Table 1
Formulations (%) of low-fat and low-sodium Bologna-type sausages.

	Control	KCl	Lys	LS	Lys + LS
Pork meat	65	65	65	65	65
Pork back fat	10	10	10	10	10
Fat replacer[a]	10	10	10	10	10
NaCl	2.5	1.25	1.25	1.25	1.25
KCl	0	1.25	1.25	1.25	1.25
Lysine	–	–	1	–	1
Liquid smoke	–	–	–	0.1	0.1
Sodium nitrite	0.015	0.015	0.015	0.015	0.015
Monosodium glutamate	0.3	0.3	0.3	0.3	0.3
Sodium tripolyphosphate	0.3	0.3	0.3	0.3	0.3
Coriander	0.2	0.2	0.2	0.2	0.2
Garlic	0.5	0.5	0.5	0.5	0.5
Black pepper	0.1	0.1	0.1	0.1	0.1
Sodium erythorbate	0.025	0.025	0.025	0.025	0.025
Crushed ice	11.06	11.06	10.06	10.96	9.96
Total	100	100	100	100	100

Batches: Control: 2.5% NaCl; KCl: 1.25% NaCl, and 1.25% KCl; Lys: 1.25% NaCl, 1.25% KCl, and 1% lysine; LS: 1.25% NaCl, 1.25% KCl, and 0.1% smoke liquid; Lys + LS: 1.25% NaCl, 1.25% KCl, 1% lysine, and 0.1% liquid smoke.

[a] Pork skin: water: green banana flour (1:2:2). Chemical composition: Pork (moisture: 72.32% ± 0.34; protein: 22.53% ± 0.63; fat: 4.15 ± 0.35); pork back fat (moisture: 13.42% ± 0.34; protein: 8.15% ± 0.34; fat: 78.67 ± 0.21); Fat replacer (moisture: 48.28% ± 0.08; protein: 10.34% ± 0.32; fat: 0.73 ± 0.08).

2.3. Technological properties

Cooking loss was determined in five replicates for each treatment according to the methodology proposed by Parks and Carpenter (1987) with some modifications. Approximately 50 g of batter was stuffed into collagen casings (Viskase, 40 mm ø) and heated at 70 °C for 60 min. After cooling in a water-ice bath for 60 min, the cooked sausages were weighed and the percentage cooking loss was calculated as follows: (weight of sausage before cooking – weight of sausage after cooking)/weight of sausage before cooking × 100.

Emulsion stability was determined in five replicates for each treatment using the methodology proposed by Colmenero, Ayo, and Carballo (2005), with some modifications. Pre-weighed graduated tubes (Citoplast; volume, 15 ml; Graduated units, 0.1 ml) were filled with approximately 5 g batter and centrifuged (1134*g*, 5 min at 5 °C). Then, the samples were heated in a boiling water bath for 40 min. The tubes were cooled in an ice bath to approximately 4 °C to facilitate the separation of fat and water layers. The total amount of fluid released was expressed as a percentage of the sample weight. The released fat was determined by the difference in the total liquid released after drying in an oven at 105 °C for 16 h. Water released by evaporation was also expressed as a percentage of the sample weight.

Texture profile analysis (TPA) was carried out using a TA-TX2 Texture Analyzer (Stable Micro Systems Ltd., Surrey, England) with a load cell of 25 kg. Fifteen cylinders per batch were used. Samples (2 cm thick and 2 cm in diameter) were axially compressed into two consecutive cycles of 75% compression, with a 30-mm diameter probe, at a constant speed of 1 mm/s. Data were analyzed for hardness (N) (expressed as peak force for the first compression), springiness (dimensionless) (measured as ratio between the distance (mm) covered by the probe before touching the sample in the 2nd vs 1st cycle), cohesiveness (expressed as the area of work during the second compression divided by the area of work during the first compression), and chewiness (N) (defined as the product of hardness × cohesiveness × springiness).

2.4. Physicochemical analysis

Fat, moisture, protein and ash contents were analyzed in triplicate using three sausages per treatment according to the Association of Official Analytical Chemists (AOAC, 2002a; AOAC, 2002b; AOAC, 2002c and AOAC, 2002d). The concentrations of sodium and potassium were determined using an inductively coupled plasma optical emission spectrometer (ICP OES) (Vista MPX, Varian, Mulgrave, Australia), according to the methodology described by the AOAC (2005). The operating conditions of the ICP OES equipment were: potency, 1000 W; nebulizing rate, 0.9 L/min; flow rate of argon and the auxiliary gas, 1.5 and 15 L/min; integrating and reading times, 10 and 3 s; number of replicates, 3. The wavelengths (nm) used were: Na, 589.592; K, 766.491.

The pH was measured using a pH MA-130 m (Mettler Toledo Indústria and Comércio Ltda, SP, Brazil). Water activity (aw) was measured in a Decagon Aqualab apparatus (Decagon Devices Inc., Pullman,