ARTICLE IN PRESS

Food Structure xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Food Structure

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

The effect of sodium reduction on the microstructure, texture and sensory acceptance of Bologna sausage

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ARTICLE INFO

Keywords:
Meat product
Healthy
Sodium substitute
JAR

ABSTRACT

The aim of this study is to evaluate the effects of different levels of sodium reduction on the physicochemical characteristics, microstructure and sensory acceptance of Bologna sausages. Four different treatments were processed: control (2% NaCl), T20, T40 and T60 (20, 40 and 60% replacement of NaCl with a commercial substitute PuraQ® Arome Na4, respectively). The physicochemical characteristics (proximate composition, sodium content and emulsion stability), physical (instrumental texture and color), microstructure (SEM) and sensory acceptance using a 9-point hedonic scale and just-about-right scale for salty taste were evaluated. The results showed that reduction of sodium by 34.64% (T40) did not affect characteristics of Bologna sausages. However, a reduction of 43.27% sodium (T60) affected the Bologna microstructure, emulsion stability and instrumental texture, causing a reduction in consumer acceptance. It can be concluded that a 40% replacement of salt in the tested conditions could be indicated, in order to obtain a healthier product yet retaining good sensory quality.

1. Introduction

Excessive sodium intake is related to high blood pressure and consequently an increased risk of stroke and death from vascular disease (Vollmer et al., 2001). The World Health Organization (WHO) has established that the consumption of more than 6 g of NaCl/person/day is associated with an increase in blood pressure. It is therefore recommended that the total amount of salt (sodium chloride) in the diet should be below this level for adults as age increases. In Brazil, salt intake exceeds the WHO recommendations, particularly due to consumption of processed with is consider as the biggest source of sodium (Associação das Indústrias da Alimentação, 2013).

Although meat products are consider as one of the main foodstuff associated to sodium intake in modern diets, sodium chloride has an important role in taste, texture and shelf-life of muscle products. Several studies have been carried out with a view to reducing the amount of sodium in these products but results show that there are major difficulties in emulsion stability and taste acceptance by consumers (Ruusunen & Puolanne, 2005).

One way to reduce the sodium content in meat products is substituting the sodium chloride by other ingredients (Terrel, 1983). Ruusunen et al. (2003) observed that Bologna formulated with less than 1.4% NaCl requires additional ingredients to obtain adequate physicochemical and sensory characteristics. The technological, microbiological and sensory impact of sodium reduction in sausages was studied by Yotsuyanagi (2014), who found that sodium reduction of approximately 25% did not affect these characteristics.

Carraro et al. (2012) studied the effect of replacement of sodium chloride by potassium chloride in reduced NaCl Bologna sausage. The formulations with less than 50% of replacement had similar emulsion stability, texture and microbiological characteristics to commercial formulation (2%). However, sensory quality and purchase intent was impaired by 50% sodium substitution

According to Desmond (2006), the largest salt substitute used in meat products is potassium chloride, although it has been observed that this substitute attributes residual bitter to the products. Different studies have been reported to reduce or replace sodium in emulsified meat products, but it is a major challenge for the meat industry due to a

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http://dx.doi.org/10.1016/j.foostr.2017.05.002
Received 8 November 2016; Received in revised form 16 May 2017; Accepted 23 May 2017
2213-3291/

Please cite this article as: Pires, M.A., Food Structure (2017), http://dx.doi.org/10.1016/j.foostr.2017.05.002

number of functional properties in salt which ensure the physico-chemical, microbiological and sensory characteristics, affecting the stability and shelf-life of the product (Desmond, 2006; Nowak et al., 2007; Ruusunen & Puolanne, 2005; Ruusunen et al., 2003; Saldaña et al., 2015).

Commercial products such as flavor enhancers or masking agents, these include yeast extracts, monosodium glutamate, lactates and flavors, may also be used as salt substitutes (Desmond, 2006).

Seganfredo et al. (2016) applied the commercial product PuraQ® Arome Na4 in order to substitute 20% and 30% of NaCl in Tuscan sausage, obtaining good results of texture and sensorial acceptance. This product was specially developed to replace salt in processed meat products, cured or not, bakery products and sauces, and also to control the water activity in them, reducing the microbial growth rate.

In this context, this study aims to develop Bologna sausages with the highest level of sodium reduction, by PuraQ® Arome Na4, while maintaining appropriate technological characteristics with high sensory acceptance by consumers.

2. Material and methods

2.1. Treatments and formulation

The sodium reduction in Bologna sausages was accomplished by replacing the added sodium chloride by commercial product called PuraQ® Arome Na4 developed by CorbionPurac for cooked and fresh meat, poultry and seafood products. This product consists of substances derived from fermentation, such as sugars, organic acids, salts and flavorings. It is liquid, pH 6–8, 27.20 ± 0.14% potassium, contains a maximum of 1% sodium, 38.3% total carbohydrates (complex or simple), 0.4% protein and 53–59% dry matter.

Four formulations were prepared in order to determine the influence of different levels of sodium chloride (NaCl) replacement by PuraQ® Arome Na4. As shown in Table 1, the following formulations were prepared: Control (Bologna without replacement of sodium chloride); T20, T40 and T60 (Bologna sausages with 20%, 40% and 60% sodium chloride replacement, respectively). Since the amount of NaCl in Control was set in 2% and the known concentrations of NaCl in curing salt and spice mix, the additional amount of additional commercial NaCl was calculated. Salt was substituted by 0, 0.4, 0.8 and 1.2% of the PuraQ® Arome NA4 in order to obtain products with 0 (control), 20, 40 and 60% NaCl reduction.

Bologna sausages were prepared using lean beef meat and pork backfat purchased in a local supermarket. The spice mix (BRC Ingredients Ltd) contained sodium chloride (40%), sodium tripolyphosphate, sodium erythorbate, spices and natural flavors (at unknown proportions). The other ingredients were curing salt (Doremus Alimentos Ltda.), cassava starch (Yoki brand, General Mills Brazil) and sodium chloride (Cisne brand, Refinaria Nacional de Sal S.A.).

Table 1
Formulations of Bologna treatments with reduced sodium.

	Control (%)	T20 (%)	T40 (%)	T60 (%)
Lean beef meat	55	55	55	55
Pork backfat	30	30	30	30
Cassava starch	5	5	5	5
Salt (NaCl)	1.375	0.975	0.575	0.175
PuraQ® Arome NA4	0	0.4	0.8	1.2
Curing salt	0.25	0.25	0.25	0.25
Spice mix	1.00	1.00	1.00	1.00
Water (ice)	7.375	7.375	7.375	7.375
Total	100	100	100	100

2.2. Bologna sausage processing

The meat products were developed and processed in a pilot plant (University of São Paulo, Brazil) following the procedures of Trindade et al. (2010). Both the beef meat and pork backfat were placed in a cutter, mixed with salt, spice mix, cure salt, starch and water (PuraQ® Arome NA4 was added with the water), comminuted for about 5 min and removed from the machine with a mass temperature around 12 °C. The emulsions were stuffed in plastic casings and cooked in a smokehouse until the internal temperature reached 72 °C. After cooking, the Bolognas were cooled in a cold-water shower and stored at 4 °C ± 1 °C until further analysis.

2.3. Sodium content analysis

The determination of sodium contents was performed in an atomic absorption spectrophotometer (Model AA100) and results were expressed as a percentage. To perform the analysis, 4 g of each sample were incinerated in a muffle furnace at 550 °C/96 h. The ashes were dissolved with 20–30 mL of 50% HCl solution, left rest for 20 min, transferred to a volumetric flask and adjusted to 100 mL with deionized water. All analyses were performed on mineral aliquots of this solution.

2.4. Emulsion stability

The emulsion stability was evaluated according to Parks and Carpenter (1987), as follows: A package containing 100 g of the sample from the recently processed mixtures (just before stuffing and cooking) was cooked in a bath of water at 70 °C/60 min. The total amount of released liquid was expressed as a percentage of the sample weight.

2.5. Emulsion microstructure

The microstructure of different treatments was examined by scanning electron microscopy (SEM), according to the methodology proposed by Haga and Ohashi (1984) in a table top microscope (TM3000, HITACHI, Japan). The Bolognas were fixed by the lyophilization procedure described by Behmer, Castro, and Freitas (1976) and Gahan (1984). A large number of micrographs were taken in order to select the most representative ones.

2.6. Proximate composition, pH values and water activity

Moisture, ash, protein and fat content were determined according to Association of Official Analytical Chemists (AOAC, 2005). Moisture (950.46) was determined by drying a 5 g sample at 105 °C to constant weight (aprox. 24 h). The estimation of ashes content were carried out in a muffle furnace at 550 °C for 96 h (920.153), protein (981.10) was analyzed by the Kjeldahl method and fat (991.36) content was estimated according to the methodology indicated by Bligh and Dyer (1959). The pH was determined using a pHmeter (Model HI 99163, HANNA Brand) with combined electrode configurated to performe readings in 3 different places on each sample. The water activity (aw) was measured by an Aqualab water activity meter (Decagon, Pullman, USA). Each treatment was evaluated in triplicate, and each analysis was performed at room temperature.

2.7. Internal color

The Bologna sausages were evaluated for internal color in CIE-lab coordinates using a Hunter-Lab Miniscan colorimeter (Minolta, Japan). The evaluation consisted of determining the parameters L* (lightness), a* (redness), b* (yelloness), using a D65 illuminant angle of observation at cell 10, opening to 30 mm to calculate the average values of 10 readings.