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Improving sensory acceptance and physicochemical properties by ultrasound application to restructured cooked ham with salt (NaCl) reduction

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ABSTRACT

The objective of this research was to study the effects of salt reduction and the application of ultrasound (nominal current of 600 W cm^{-2} for 10 min) on the physicochemical properties, the microstructure and the sensory acceptance of restructured cooked ham. Four treatments with reduced salt including one with the application of ultrasound (1.5, 1.12, 0.75 and 0.75% salt + ultrasound) were produced. The treatment with 0.75% salt provided a reduction of about 30% in the sodium content. The use of ultrasound decreased the Total Fluid Release and increased the hardness. For lightness, the sample with 0.75% salt with the application of ultrasound did not differ from the control at day zero of storage. The use of ultrasound increased redness too. The ultrasound treatment caused micro fissures on the myofibrils. The sensory acceptance of restructured cooked ham with 0.75% of salt was improved with ultrasound applied. The ultrasound showed good potential for use in the production of healthier meat products.

1. Introduction

Most pork consumed in Brazil is in processed products, since 89% of this meat is industrialized in various products such as salami, sausages, restructured cooked ham and cooked restructured pork shoulder (ABPA, 2016). On the world stage, restructured cooked ham also appears as one of the most popular meat products among consumers (Válková, Saláková, Buchtová, & Tremlová, 2007). Restructured cooked ham is produced exclusively from boned prime leg of pork with added ingredients and subjected to a suitable cooking process (Brazil, 2000). The ingredients used in the formulation aim to improve the product characteristics, such as salt (NaCl), which plays an essential role in the water holding capacity, the lipid retention properties, color, flavor and texture as well as playing a part in the extraction of myofibrillar proteins and contributing to the shelf life of meat products (Ruusunen & Puolanne, 2005).

Sodium chloride is the major source of dietary sodium (Wentzel-Viljoen, Steyn, Ketterer, & Charlton, 2013), and excessive sodium intake is related to increased blood pressure. This increases the risk of strokes and death from vascular diseases (Iser, Claro, Moura, Malta, & Neto, 2011; Vollmer et al., 2001). In this sense, there is a need to reduce the use of salt in processed meat products. However, salt reduction should not occur without effective studies, due to its technological and sensory importance for the development of meat products (Ruusunen & Puolanne, 2005). Some studies (Bis et al., 2016; Carraro, Machado, Espindola, Campagnol, & Pollonio, 2012) tested reformulations of meat products, partially substituting sodium chloride by potassium chloride and the results showed the possibility of producing products with lower sodium content without compromising the technical and sensory qualities. However, when used principally on its own, some studies report that KCl can damage the sensory acceptance of meat products by promoting bitterness, astringency and metallic taste (Askar, El-Samahy, & Tawfic, 1994; Geleijnse, Kok, & Grobbee, 2003; Gelabert, Gou, Guerrero, & Arnau, 2003).

Alternative technologies have been studied aiming to promote the functional properties of food products, added to the convenience of less processing time, less water, less energy expenditure and less production of effluents and toxic substances. In this context, new processing technologies such as microwaves, pulsed electric fields, high hydrostatic pressure, ultraviolet light, ohmic heating and ultrasound are inserted

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(Chemat, Zill, & Khan, 2011; Leadley & Willians, 2008). With respect ultrasound, several studies report (Cárcel, García-Pérez, Benedito, & Mulet, 2012; Jayasooriya, Torley, D'arcy, & Bhandari, 2007; McDonnell, Lyng, & Allen, 2014b; Vimini, Kemp, & Fox, 1983) that this technology can be useful to accelerate and intensify the extraction and diffusion of sodium and, thus, reduce the processing time. Cárcel, García-Pérez, Benedito, and Mulet (2012) emphasizes that the technology of ultrasound enables innovation in the industry by saving energy and increasing the yield and quality of the final products, meaning that this technology opens up a whole new field in food processing.

Ultrasound waves can be classified as high and low energy. Those of high energy have low frequency (20–100 kHz) and develop higher power levels (10–1000 $W{\cdot}cm^{-2}$), sufficient to break intermolecular bonds, with intensities > 10 $W{\cdot}cm^{-2}$ producing a cavitation phenomenon, able to change some physical properties, catalyze chemical reactions (Jayasooriya, Torley, D'arcy, & Bhandari, 2007) and improve mass transfer processes (Ojha, Keenan, Bright, Kerry, & Tiwari, 2016). So, the objective of this study was to study the effects of salt reduction and the use of ultrasound on the physicochemical properties, microstructure and sensory acceptance of restructured cooked ham.

2. Materials and methods

2.1. Restructured cooked ham manufacture

Topside ham *(semimembranosus* and *adductor* muscles*)* (70.1% moisture content, 21.43% protein content and 6.9% lipid content) was obtained from a local slaughterhouse (Slaughterhouse "Olhos D'água", Ipuã, Sao Paulo, Brazil). The meat was received frozen at −18 °C, ground using a kidney plate into pieces measuring 3 × 3 cm, vacuum-packed and maintained in this condition for 24 h. Thawing occurred in a refrigerator at 4 °C for 48 h before the start of the processing of the ham.

The amount of sodium chloride in Brazilian restructured cooked ham is variable typically around 1.5% - 2%. So, 1.5% was chosen as the salt content used as the control. Four treatments were made for restructured cooked ham - T100: 1.5% NaCl; T75: 1.12% NaCl; T50: 0.75% NaCl and; T50US: 0.75% NaCl and subjected to ultrasound - 10 min in a nominal current of 600 $W{\cdot}cm^{-2}$. The topside ham was mixed with brine, which was made by homogenizing of 1.5% soybean isolate protein (Bremil, Lajeado, Brazil), 0.94% sodium-free California condiment (Fego, Goiânia, Brazil), 0.1% monosodium glutamate (Ajinomoto, São Paulo, Brazil), 0.02% cochineal carmine dye (Christian Hansen, Hoersholm, Denmark), 0.28% curing salt (Kraki, Santo André, Brazil - 10% sodium nitrite and 90% sodium chloride), 0.19% sodium erythorbate (NewMax, Americana, Brazil), 0.47% sodium tripolyphosphate (NewMax, Americana, Brazil), 0.47% sucrose (União, Sertãozinho, Brazil), 0.24% carrageenan (Indukern, Jundiaí, Brazil), 0.28% maltodextrin (Ingredion, Mogi Guaçu, Brazil). All the ingredients for the brine were mixed in a homogenizer (Fisatom, São Paulo, Brazil). The percentages of water and salt (sodium chloride) for each treatment are shown in Table 1. After the topside ham and brine had been mixed, T100, T75 and T50 were massaged in a tumbler (Frigomaq, Chapecó, Brazil) for 60 min (15 rpm).

T50US was subjected to ultrasound and then also massaged in the same tumbler under the same conditions as the other treatments. To apply the ultrasound in T50US, the incorporated ingredients were packed in a cylindrical stainless steel vat (21 cm diameter, 42 cm high) that was immersed in an ice bath and then subjected to the ultrasound waves. The system comprised a VCX-1500 ultrasound processor (Sonics & Materials Inc., Newtown, USA) which emits waves at a frequency of 20 kHz. The processor was equipped with a Ti-6Al-4 V titanium probe that emits ultrasound in both the axial and radial directions (Sonics & Materials Inc., Newtown, USA). The probe was immersed in the mixture and positioned in the center of the vessel.

0.8 kg portions of each treatment were embedded in a 95 mm plastic casing (Viscofan, Navarra, Spain) and accommodated in stainless steel molds for ham. They were kept at rest at 4 °C for 60 min. Subsequently, the molds were immersed in water at 25 °C in a cooking tank (Frigomaq, Chapecó, Brazil). After immersion, the temperature was adjusted to 80 °C. The cooking cycle ended when the ham reached 72 °C at its thermal center and it was promptly cooled by immersion in iced water for sixty minutes. The hams were stored at 4 °C until the beginning of the analyses. Ten restructured cooked hams were prepared per treatment in each batch. Three independent batches of the restructured cooked hams were prepared on three different days.

Table 1
Percentual of water and salt of cooked ham.

Ingredients	Treatments (%)			
	T100	T75	T50	T50US
Water	31.52	31.89	32.27	32.27
Salt – NaCl	1.5	1.12	0.75	0.75

T100 = 1.5% NaCl; T75 = 1.12% NaCl; T50 = 0.75% NaCl; T50US = 0.75% NaCl and ultrasound.

2.2. Proximate analysis, pH and sodium content

Moisture, ash and protein contents were determined according to the AOAC (2007) method. The lipid content was determined, following the methodology described by Bligh and Dyer (1959). Total carbohydrates were determined by a difference calculation. The pH was measured in triplicate for each treatment using a PG 1800 digital pH meter (Gehaka, Sao Paulo, Brazil) that was calibrated with two standard solutions (pH 4 and pH 7) at room temperature, at zero-day cold storage used by inserting the probe in the piece of restructured cooked ham. The sodium content was analyzed using dry digestion (Horwitz, 2010). The homogenized samples were weighed, pre–calcinated on a hot plate and incinerated in a muffle furnace at 450 °C until the ash, free of black spots, formed. The ash was quantitatively transferred to a volumetric flask with nitric acid solution 5% (v/v) and the reading was performed using a DM-62 flame photometer (Digimed Analytical Group, São Paulo, Brazil). All assays were performed in triplicate.

2.3. Total fluid release (TFR)

This evaluation shows the water retention capacity in the period after cooking and also during cold storage. The hams were partially opened at one end and placed over a 250 ml beacker for 10 min to collect all the exuded liquid. TFR (%) was measured in triplicate after zero and sixty days of refrigerated storage by subtracting the weight of the ham after cooking and draining (W2) from the total weight of the ham before cooking (W1), expressed as a percentage of the total weight before cooking, according to Eq. (1).$\text{TFR}\,(\%) = \dfrac{W1 - W2}{W1} \times 100$

2.4. Instrumental color

Instrumental color was measured using a Colorflex EZ 45/0 spectrophotometer (HunterLab, Reston, US) calibrated using the black glass and white tile provided. Samples were analyzed in a 2.5 in. glass sample cup, with a 1.25 in. port insert, illuminant D65, at room temperature. The color was expressed in L* for lightness, a* for redness and b* for yellowness. Four measurements were obtained for each parameter at equidistant points, by rotating the capsule. The mean of the measurements represented the reading for each sample. The measurements were performed after zero and sixty days of refrigerated storage.