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High pressure as an alternative processing step for ham production

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ABSTRACT

As high pressure processing (HPP) is becoming more and more important in the food industry, this study examined the application of HPP (500 and 600 MPa) as a manufacturing step during simulated ham production. By replacing conventional heating with HPP steps, ham-like texture or color attributes could not be achieved. HPP products showed a less pale, less red appearance, softer texture and higher yields. However, a combination of mild temperature (53 °C) and 500 MPa resulted in parameters more comparable to cooked ham. We conclude that HPP can be used for novel food development, providing novel textures and colors. However, when it comes to ham production, a heating step seems to be unavoidable to obtain characteristic ham properties.

1. Introduction

Over the last decades, high pressure processing (HPP) has become increasingly important in the food sector as a minimal processing technology (Medina-Meza, Barnaba, & Barbosa-Cánovas, 2014). Along with pulsed electric fields (Boulaaba, Egen, & Klein, 2014; Boulaaba, Kiessling, Töpfl, Heinz, & Klein, 2014), HPP is considered a non-thermal process technology. In contrast to traditional thermal food processing, HPP acts instantaneously and uniformly throughout the food matrix independently of size and composition (Torres & Velazquez, 2005). Therefore, processing times can be shortened and manufacturing cost can be reduced (Lickert et al., 2010). Additionally, HPP treatments are able to reduce or eliminate vegetative microorganisms so that food safety can be assured (Balasubramaniam & Farkas, 2008). However, product quality can also be negatively affected by increasing lipid oxidation and muscle discoloration (Cheftel & Culioli, 1997). Therefore, high pressure has been used in combination with sodium chloride and phosphate to enhance texture, water retention and color of pork meat (Villamonte, Simonin, Duranton, Chéret, & de Lamballerie, 2013). Besides using HPP as a post-processing preservation method (Garriga, Grèbol, Aymerich, Monfort, & Hugas, 2004; Slongo et al., 2009), it also offers the possibility of generating new food products with novel structures and textures (Lickert et al., 2010; Yang et al., 2015). Ma and Ledward (2004) assumed that texture formation could be enhanced by the simultaneous or sequential treatment of proteins with heat and pressure. Color and texture changes observed in HPP treated meats are mainly associated with denaturation of proteins (Khan et al., 2014). As shown by Sikes, Tobin, and Tume (2009), pressure enhances the solubility of myofibrillar proteins, resulting in texture changes. Through gentle heating temperatures, cooking loss can be reduced and juiciness increased (Aaslyng, Bejerholm, Ertbjerg, Bertram, & Andersen, 2003), which is a decisive parameter for customer acceptance (Aaslyng et al., 2007). As shown by Patterson and Kilpatrick (1998), elevated temperatures and pressure could be used to decrease the pressure resistance of bacterial strains. Therefore, low temperatures followed by pressure treatment can be used as a hurdle principle, regarding microbiological safety, while new textures and flavors might occur. Our study investigated physico-chemical and microbiological changes of cured *M. longissimus thoracis et lumborum* (LTL) which was pressure-treated (500 and 600 MPa), heat-treated (53 °C) and pressure- plus heat-treated (53 °C and 500 MPa). Although classical ham production uses muscles of the hind leg, LTL was chosen as model muscle. Both LTL of one pig per trial were processed to compare meat samples more consistently, as physicochemical differences in multiple muscles and animal individual properties were minimized. All treatments were compared with a conventional ham production method (67 °C). The aim was to develop an acceptable ham-like pork product by means of high-pressure technology.

2. Materials and methods

2.1. Sample preparation

For each of the six replications the pork loins of one commercial crossbreed pig were obtained 24 h post mortem (p.m.) from a local slaughterhouse (Fig. 1). Both loin muscles of one pig were used for each replication in order to exclude the impact of different muscles, which are normally used for ham production. The pork loins were stored for 24 h at 4 ± 1 °C. *M. longissimus thoracis et lumborum* (LTL)

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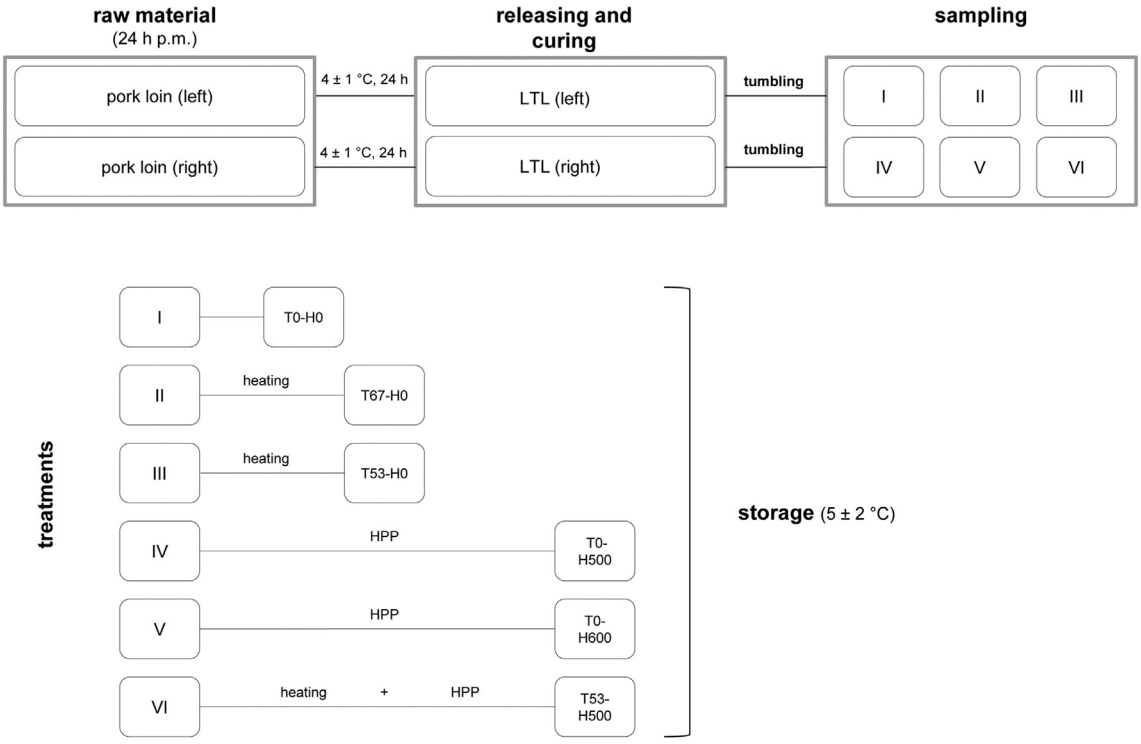

Fig. 1. Production process. Pork loins were obtained 24 h post mortem (p.m.) and were stored for 24 h at 4 ± 1 °C. *M. longissimus thoracis et lumborum* (LTL) was released and cured 48 h p.m. Subsequently, after tumbling, each LTL was cut into three samples. Samples were assigned to six different treatments, as listed: cured control sample (T0-H0), heat-treated samples (T67-H0 and T53-H0), pressure-treated (HPP) samples (T0-H500 and T0-H600) and combination treatment (T53-H500).

was excised 48 h p.m. (10 °C), subcutaneous fat and connective tissues were removed.

2.2. Injection of brine

LTL was brine enhanced (0.5% nitrite, 9.5% salt, 90% water) via a single needle hand injector to obtain 20% weight gain. After injection LTL was intermittently tumbled (10 min tumbling and 20 min rest for 14 h) in a vacuum tumbler (MKR 150, Rühle GmbH, Grafhausen, Germany) under 90% vacuum, 3 °C and 10 rpm. Subsequently, each muscle was divided into three samples of similar length (approx. 16 cm) and weight (approx. 800 g). All samples were placed in cooking bags (Nalophan, Kalle GmbH, Wiesbaden, Germany) and were assigned to six different treatments (Fig. 1). A Latin-square design was randomly applied to minimize the effect of different muscle locations.

2.3. Heat treatment

Samples were heated to core temperatures of 67 °C (approx. 4 h) and 53 °C (approx. 3 h) in a combi-steamer (Joker T, Eloma GmbH, Maisach, Germany) at 100% moisture using a Delta-T cycle. After heat-treatment, samples were vacuum-sealed (99.5% vacuum, K3N, VC999 Packaging Systems, Herisau, Switzerland) in sealed-edge polyethylene pouches (PA-PE 20/70, 300 × 400 mm, vapor permeability ≤2.6 g/m^{2}d, Dagema, Willich, Germany).

2.4. High pressure processing

Samples for high pressure treatment were vacuum-sealed (99.5% vacuum, K3N, VC999 Packaging Systems, Herisau, Switzerland) in two layers of sealed-edge polyethylene pouches (PA-PE 20/70, 300 × 400 mm, vapor permeability ≤2.6 g/m^{2}d, Dagema, Willich, Germany). HPP treatment was conducted in an isostatic pressure unit (Isostatische Presse 6500 Bar 2 L, Nova Swiss, Cesson, France) with a 2 L cylindrical pressure chamber. A mixture of water and friogel (FRIOGEL®NEO, Climalife, Vincennes, France) was used as pressure medium. Target pressure was reached after approximately 5 min (500 MPa) or 7 min (600 MPa). Pressure holding time was one minute. Temperature in the pressure vessel was monitored during treatment. During pressurization adiabatic heating led to a temperature variation of 3 ± 1 °C.

2.5. Heat and pressure combination

One of the samples was heated to a core temperature of 53 °C, as described in Section 2.3. prior to HPP treatment at 500 MPa as described in Section 2.4.

2.6. Storage

All samples were stored vacuum-sealed for 28 days at 5 ± 2 °C.

2.7. Microbial examinations

Samples were microbiologically examined 24 h after treatment (day 1). The TPC (total plate count) of aerobic, mesophilic organisms was determined according to ISO 4833-1:2013. Additionally, lactic acid bacteria (LAB) were quantified according to ISO 15214:1998. Cell counts were expressed as $\log_{10}$ colony forming units per g meat ($\log_{10}$ CFU/g).

2.8. Physical analysis

Physical measurements were conducted 24 h after production (day 1) and 28 days later. Color (CIELab system, 2° standard observer, D65 illuminant, 8 mm measuring field) was measured on a fresh cut 30 min after blooming with a colorimeter (Minolta CR 400®, Konica-Minolta GmbH, Langenhagen, Germany). Each mean value was an average of 15 measuring points per sample. pH values were measured using a portable pH meter (Portamess®, Knick GmbH, Berlin, Germany) equipped with a glass electrode (InLab 427®, Mettler-Toledo, Urdorf, Switzerland). Mean values of triplicate measurements were calculated. a_w value was