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Pulsed pressure assisted brining of porcine meat

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ABSTRACT

Pulsed pressure (PP) is an emerging food processing technology, which is scarcely used in food processing, especially in meat salting. In this study, pork loins were brined using a PP apparatus in order to accelerate the brining rate and improve the product's texture properties. The pulsed pressure cycle was 150 kPa (holding 40 min), atmospheric pressure (holding 20 min), and number of pressure pulses 12. The results indicated that PP assisted brining could effectively shorten the brining time on the basis of reaching the same salt content as the control brined samples (brined at atmospheric pressure). The basic chemical composition and freshness were not markedly affected by PP. The texture profile (hardness, springiness and gumminess) of the PP brined samples was highly improved compared with the control brined samples ($P < 0.05$). PP assisted brining appears as a promising technology in the meat processing industry in the near future.

Industrial relevance: PHP assisting brining could effectively shorten the brining time to about 70% compared to brining at the atmospheric pressure. The water holding capacity was significantly increased, which could consequently improve the production rate. The texture profile (hardness, springiness and gumminess) of the PHP treated samples was highly improved compared with the control samples ($P < 0.05$). So, PHP will be a promising technology in the meat processing industry in the near future.

1. Introduction

Salting of meat has long worldwide traditions as a preliminary operation in smoking, drying and cooking processes. This aids in enhancing product texture, flavor and shelf life (Graiver, Pinotti, Califano, & Zaritzky, 2006). The traditional meat salting technologies are usually divided into two modes of dry-salting and wet-salting according to the physical state of salting agents. Dry salting is done by rubbing the curing mixture (mainly sodium chloride, nitrate and/or nitrite, sugars and spices) onto the surface of the meat; wet salting is done by plunging the product into brine or injecting the solution directly in the muscle meat (Varnam & Sutherland, 1995). The salt content of dry-cured products may be high and of low homogeneity, which consequently causes the poor sensory quality and great quality fluctuation of salted meat products. Whereas, brining, to some extent, can help in avoiding these phenomena. Different brining techniques have been proposed to accelerate salt transport through the product, for instance high intensity ultrasound brining (Cárcel, Benedito, Bon, & Mulet, 2007), pulsed vacuum brining (Deumier, Bohuon, Trystram, Saber, & Collignan, 2003), and tumbling (Katsaras & Budras, 1993).

Application of high-pressure processing is initially investigated in meat processing for microbial inactivation, meat tenderization, gelation or lipid oxidation (Lamballeric-Anton, de Taylor, & Culioli, 2002). But in recent years, moderate application of pressure has been reported to accelerate the diffusion of components into the food. Villacís, Rastogi, and Balasubramaniam (2008) found that pressure treatment could result in a 10-fold increase in NaCl diffusion coefficient in turkey meat in comparison to salting at ambient pressures. However, the repeated pressure pulse has not been used in brining of meat to accelerate salt diffusion.

Thus, this study brined pork loin using a PP equipment in order to reduce the salting time and salting effect. The effect of pulsed pressure on meat was evaluated by determining the basic components, physico-chemical indices, textural properties and free amino acids and compared them with the control samples.

2. Materials and methods

2.1. Sample preparation and brining

Pork loin with a weight of 5–6 kg was purchased from a local butcher. Immediately after purchase, the loins were frozen separately in a freezer for 10 h at −40 °C and then kept at −18 °C until use. Before

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treatment, the pork loins were thawed for 24 h at 4 °C and then chilled slightly to rigidify before slicing. They were then trimmed off the fascia and connective tissues and cut into 10 parallelepiped 20 cm × 5 cm × 5 cm, with an average weight of 500 g. All meat pieces were randomly divided into two groups with each group consisting five pieces, one group as treatment samples and the other group as control samples.

The solution used for meat brining was formulated with demineralized water and sodium chloride (80 g/kg solution), sodium nitrite (0.02 g/kg), mixed phosphate (3 g/kg solution, sodium tripolyphosphate:sodium pyrophosphate:sodium hexametaphosphate 2:2:1), sodium erythorbate (0.25 g/kg) and high alcohol (60°) liquor (15 g/kg g solution).

The samples of treatment group and control group were separately brined under PP conditions (Fig. 1) and atmospheric pressure conditions in brining solution with a 1:2 (g:g) ratio of meat:brining solution. The pulsed pressure cycle was 150 kPa, holding time 40 min; atmospheric pressure, holding time 20 min; number of pressure pulses 12 and ramp rate 10 kPa/s. The brining time of control samples was 12 h, and the brining solution was stirred every hour in order to keep the brining solution components homogeneous. After brining, all samples were immediately taken out and the surface was dried for analysis.

2.2. Basic component analysis

After brining, the brine residue on the surface of the meat was sipped up by using filter paper, and then the visible fat and connective tissues were trimmed off from the samples. The moisture, protein, fat and ash contents (g/100 g meat) of each sample were determined according to the AOAC official methods (AOAC, 2000). The sodium chloride content was measured using a chloride analyzer (Corning, model 926) after extraction in 0.3 N nitric acid (Bohuon, Collignan, Rios, & Raoult-Wack, 1998). Each analysis was done in five replications.

2.3. Physico-chemical analysis

The pH was determined directly with a Crison model 2001 pH-meter (Crison Instruments S.A., Barcelona, Spain) equipped with a combined electrode (Cat. No. 52, Crison Instruments S.A., Barcelona, Spain), inserting the electrode in three different parts of the muscle samples.

The cooking loss of each sample was determined according to the method reported by Bond and Warner (2007) with minor modification. About 30 ± 2.0 g (raw weight) muscle from the same section of each sample was trimmed off all excess fat from blocks, and then placed in plastic bags and cooked at 75 °C for 20 min in a water bath and cooled under running water for 30 min. The samples were then dried with a paper towel and weighed (cooked weight). Cooking loss from each sample is expressed as a percentage calculated by the following equation:

$$\%\,\text{Cooking loss} = (\text{raw weight} - \text{cooked weight}) \times 100/\text{raw weight}. \quad (1)$$

2.4. Free amino acid (FAA) analysis

Samples for amino acid analysis were extracted following the method of Bidlingmeyer, Cohen, and Tarvin (1984). The samples of each treatment were hydrolyzed with 6 M HCl in a sealed tube under nitrogen for 22 h in an oil bath at 110 °C. The samples were subsequently centrifuged (1500 ×*g* for 5 min) and dried under vacuum for 1.5–2 h. Finally, the dried samples were redissolved with 0.02 M HCl and stored at −80 °C for FAA analysis. A Hitachi amino acid auto-analyzer (Model 835-50, Hitachi Co., Tokyo, Japan) was used for separating amino acids.

2.5. Myoglobin content analysis

The method of Krzywicki (1979) was used to determine the relative concentration of myoglobin, oxymyoglobin, and metmyoglobin. Two grams of muscle from each sample was homogenized in 20 mL of 0.04 M phosphate buffer, pH 6.8, for 30 s in ice-water bath. The homogenate was centrifuged at 4000 ×*g* for 30 min, at 4 °C. The supernatant was filtered through a filter paper, and was diluted to 50 mL with phosphate buffer (0.04 M, pH 6.8). Then the absorbance was read at 525, 545, 565 and 572 nm, respectively, using a Shimadzu UV-2450 spectrophotometer (Shimadzu Scientific Instruments Inc., Japan). The relative concentrations of myoglobin, oxymyoglobin and metmyoglobin were calculated by the following equations:

$$\%\text{deoxymyoglobin} = (0.369R_1 + 0.140R_2 + 0.941R_3 + 0.015) \times 100 \quad (2)$$

$$\%\text{oxymyoglobin} = (0.882R_1 + 1.267R_2 + 0.809R_3 - 0.361) \times 100 \quad (3)$$

$$\%\text{metmyoglobin} = (-2.541R_1 + 0.777R_2 + 0.800R_3 + 1.098) \times 100 \quad (4)$$

where $R_1 = A^{572}/A^{525}$; $R_2 = A^{565}/A^{525}$; $R_3 = A^{545}/A^{525}$.

2.6. Texture profile analysis

Texture profile analysis (TPA) of the samples was performed using a TA.XT2i SMS Stable Microsystems Texture Analyser (Stable Microsystems Ltd., Godalming, Surrey, England) with the Texture Expert

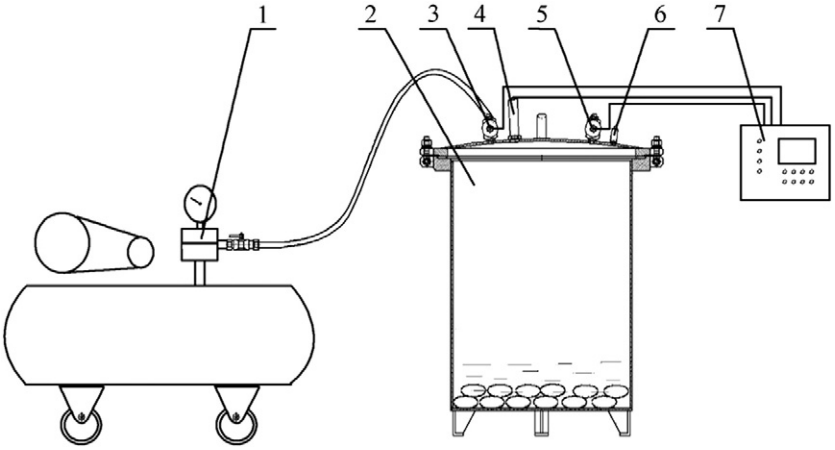

Fig. 1. Schematic diagram of the pulsed high-pressure brining equipment. 1. Air compressor; 2. Pressure vessel; 3. Pressure electromagnetic valve; 4. Pressure sensor; 5. Pressure relief electromagnetic valve; 6. Safety valve; 7. Controller. Air compressor characteristics: air flow rate was 0.1 m^3/min; rated pressure was 0.8 MPa.