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Effect of pulsed pressure-assisted brining on lipid oxidation and volatiles development in pork bacon during salting and drying-ripening

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Chemical compounds studied in this article:
Hexanal (PubChem CID: 6184)
Nonanal (PubChem CID: 31289)
1-Octen-3-ol (PubChem CID: 18827)
Decanal (PubChem CID: 8175)
(Sodium nitrite (PubChem CID: 23668193)
Malondialdehyde (PubChem CID: 10964)
Linoleic acid (PubChem CID: 5280450)
2-Thiobarbituric acid (PubChem CID: 2723628)
Potassium iodide (PubChem CID: 5475)
Trichloroacetic acid (PubChem CID: 6421)

ABSTRACT

In this study, the pulsed pressure-assisted brining technology was used for bacon brining, and its effect on the moisture and lipid oxidation changes during drying-ripening period as well as the flavor composition of final products was investigated by determining the moisture content, acid value, peroxide value, TBARS value and volatile flavor compounds in meat samples during brining and drying-ripening. The results indicated that pulsed pressure-assisted brining could effectively increase the muscle water-holding capacity and decreased the sodium nitrite residues in final cured bacons. After drying-ripening (48 h) the moisture and sodium nitrite content in pulsed pressure-assisted brined samples and control samples were 32.84%, 14.56 mg/kg dry basis and 29.81%, 18.59 mg/kg dry basis, respectively. In addition, the lipid oxidation was promoted by pulsed pressure treatment ($P < 0.05$), and thus forming more lipid oxidation originated flavor compounds (esters, alcohols and aldehydes) in the pulsed pressure-assisted brined bacons than in control bacons. These suggested that pulsed pressure-assisted brining could effectively improve the sensory quality of cured bacon.

1. Introduction

Cured bacon is a famous traditional cured meat product in China with a long history. Chinese traditional cured bacon is usually processed by salting and drying-ripening, and some kinds also need smoking. The processing time of traditional cured bacon generally takes 1–2 months (Huang, Li, Huang, Li, & Sun, 2014). During processing many physicochemical reactions occur in the bacon, which contribute to the unique flavor of final products.

Salting is a key processing step of Chinese cured bacon. The traditional methods of Chinese bacon salting is performed by rubbing the curing mixture (mainly sodium chloride, nitrate and/or nitrite, sugars and spices) on the surface of meat or by soaking the bacon in the brine solution. But both methods are time-consuming and result in high level and low homogeneity of salt in the final products, especially for the dry-salting method. So, in recent years,

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many researchers intended to explore new salting methods to accelerate the salting time and increase the salt homogeneity in cured meat. For example, intensity ultrasound brining (Cárcel, Benedito, Bon, & Mulet, 2007), pulsed vacuum brining (Deumier, Bohuon, Trystram, Saber, & Collignan, 2003). Recently, we tried to brine the pork meat by using a pulsed pressure generation equipment. The results indicated that pulsed pressure-assisted brining could effectively accelerate the salting process, and improve the textural quality of the bacon after salting (Jin et al., 2014). But the study has not studied the effect of pulsed pressure-assisted brining on the physicochemical changes of bacon meat during the following drying-ripening process step. However, these physicochemical reactions that occur during the drying-ripening step are actually very important for the quality of final cured bacon, especially for the flavor quality.

Lipid oxidation is a very important biochemical reaction in dry-cured meat products. Many studies have investigated the relationship between the muscle lipid oxidation and flavor formation in dry-cured meat products, and proved that lipid oxidation plays an important role in the formation of the final flavor of dry-cured meat products. Therefore, the main objective of this study was to investigate the influences of pulsed pressure-assisted brining on the lipid oxidation of bacon during drying-ripening step and the flavor characteristics of the final cured bacon. The results of this study will provide theoretical guidance for the pulsed pressure-assisted brining technology utilization in meat salting.

2. Materials and methods

2.1. Samples preparing and brining

Green bacon muscle from the same carcass (after 24 h post-mortem) was purchased from a local butcher. Immediately after purchase, the bacon muscle was cut into parallelepiped pieces with an average weight of 1000 g. Then three pieces were sampled as raw samples for volatile flavor analysis, and the remaining bacon pieces were randomly divided into two groups with each group containing 15 pieces. One group was brined by pulsed pressure equipment (pulsed pressured-assisted brined group) and the other group was brined under the atmospheric pressure (Control brined group).

The solution used for meat brining was the same as the previous study used (Jin et al., 2014), which was formulated with 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 grain liquor with 60% alcohol degree (15 g/kg solution).

All bacon pieces were salted in brining solution with a 1: 2 (w: w) ratio of meat: brining solution at room temperature (22 °C). For the pulsed pressure-assisted brined group, the pulsed pressure cycle was 150 KPa holding 40 min, and atmospheric pressure holding 20 min, number of pressure pulses 12 and ramp rate 10 kPa/s. The holding time of control brined group was 12 h, and the brining solution was stirred one time per hour in order to keep the brining solution components homogeneous. After brining, three bacon pieces of each group were removed for analysis. Then all the residual samples were transformed to a drying-ripening oven, and drying-ripening for 48 h at 55 °C. Three bacon pieces of each group were randomly sampled at an interval of 12 h for analysis.

2.2. Physicochemical analysis

The moisture content was determined according to ISO 1442:1997(E); the salt content was evaluated as chloride and was assayed according to ISO 1841-1:1996(E). The results of moisture and salt content were both expressed as g per 100 g muscle of each sample sampled after brining, and drying-ripening 12 h, 24 h, 36 h and 48 h, respectively.

2.3. Lipid oxidation analysis

The lipid oxidation degree was evaluated by peroxide value (PV), acid value (AV) and thiobarbituric acid reactive substances value (TBARS).

2.3.1. Extraction of lipid

Lipids were extracted according to Folch, Lees, and Sloane-Stanley (1957) method by homogenizing 20 g of minced muscle in 250 mL of $CHCl_3$: MeOH (2:1 v/v). The extracts were dried under vacuum in a rotary evaporator and dry finished with a nitrogen flow. Then the lipid extracts were stored at −40 °C for peroxide value (PV) and acid value (AV) determination.

2.3.2. Analysis of peroxide value

Peroxide value (PV) of lipid sample was determined following the Chinese national standard (GB/T 5538-1995). The lipid sample (1.0 g) was treated with 30 mL organic solvent mixture (chloroform: acetic acid mixture, 2:3). After vigorously shaking, 0.5 mL of saturated potassium iodide solution was added to the mixture. The mixture was kept in the dark for 5 min and 75 mL of distilled water were added and the mixture was shaken up. To the mixture, 0.5 mL of starch solution (1%, w/v) was added as an indicator. The PV was determined by titrating the iodine liberated from potassium iodide with standardized 0.01 mol/L sodium thiosulfate solution. The PV was expressed as mmol peroxide/kg lipid.

2.3.3. Analysis of acid value (AV)

The AV of the samples was determined according to the AOAC (2000) method. Description in brief: the sample (0.5 g) is dissolved in a mixture of 100 mL of ethanol and diethyl ether (1:1, v/v) and titrated with 0.01 mol/L potassium hydroxide solution. Phenolphthalein was used as the indicator. The result of acid value was expressed as mg KOH/g lipid.

2.3.4. Thiobarbituric acid-reactive substances (TBARS) analysis

Thiobarbituric-reactive substances (TBARS) were determined following the method of Du, Nam, Hur, Ismail, and Ahn (2002) with minor modifications. Minced muscle samples (5 g) were placed in a 80 mL test tube and homogenized with 15 mL deionized distilled water using a Polytron (4 × 15 s at 3000 rpm) homogenizer (IKA T18 basic, Made in IKA, Germany). The homogenate (1 mL) was transferred to a disposable test tube (13 × 100 mm) and butylated hydroxytoluene (BHT, 7.2%, 50 μl) and thiobarbituric acid/trichloroacetic acid (15 mM TBA/15% TCA, 2 mL) solution was added. The mixture was vortexed and then incubated in a boiling water bath for 20 min to develop color. After cooling for 10 min in cold water, the sample was centrifuged at 2000 × g for 10 min at 4 °C. The absorbance of resulting upper layer was determined at 532 nm against a blank containing 1 mL deionized distilled water and 2 mL thiobarbituric acid (TBA)/trichloroacetic acid (TCA) solution. The TBARS values were calculated from the standard curve, and expressed as mg of malonaldehyde (MDA) per kg of sample.

2.4. Volatile flavor compounds analysis

Volatile compounds were extracted from the headspace (HS) of the bacon samples by using a solid-phase microextraction (SPME) fiber (Supelco, Bellefonte, PA, USA) coated with a 75 μm layer of divinylbenzene/carboxen/polydimethylsiloxane) (DVB/CAR/PDMS).