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Effect of Maillard reaction products derived from the hydrolysate of mechanically deboned chicken residue on the antioxidant, textural and sensory properties of Cantonese sausages

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ABSTRACT

Protein hydrolysates as precursors of Maillard reaction were obtained via enzymatic hydrolysis of mechanically deboned chicken residue (MDCR). The Maillard reaction products (MRPs) were prepared at 90 (M1), 100 (M2), 110 (M3) and 120 °C (M4), respectively. MRPs possessed a strong reducing power and 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging activity. According to the evolution of total free fatty acids and peroxide value of Cantonese sausage with MRPs during storage, M1 and M3 had a potent antioxidant activity ($P<0.05$) due to their antioxidant abilities and inhibitory action against lipolytic enzymes. Cantonese sausages treated with M1 and M2 showed good textural and sensory properties. However, M3 and M4 had a negative ($P<0.05$) effect on the flavour and texture of Cantonese sausages compared to control. The results suggested that M1 was very potential to be used to improve their antioxidant, textural and sensory quality.

1. Introduction

Mechanically deboned chicken residue (MDCR) is a processing waste of poultry processing industry. During the mechanical deboning process a ground slurry of chicken meat and bones is put into a mechanical deboner wherein pressure is used to separate meat and soft tissue from the rest of the bony material. This residue still contains a large amount of proteins (ca. 15–20%) and has been recognized as a valuable source of proteins for food. Enzymatic hydrolysis is potentially an effective technique for the recovery of proteins from MDCR (Fonkwe & Singh, 1996).

The lipid oxidation directly affects the quality of dry cured meat product and is commonly associated with changes in flavour and texture of these products (Ordóñez, Hierro, Bruna, & De la Hoz, 1999). Therefore, prevention of lipid oxidation is of important concern in the meat industry. Maillard reaction is a non-enzymatic interaction between reducing sugar and amino acid, peptide or protein, resulting in a variety of by-products, intermediates and brown products (melanoidins), which contribute markedly to the aroma, taste and colour, as well as to the antioxidant potential of stored and processed foods (Alfawaz, Smith, & Jeon, 1994; Bedinghaus & Ockerman, 1995; Lertittikul, Benjakul, & Tanaka, 2007; Mottram, 1998). In addition, Maillard reaction between proteins and reducing sugars is a chemical method to improve the functional properties of proteins. The modified proteins (MRPs) have often showed better solubility and improved emulsifying properties (Oliver, Melton, & Stanley, 2006). The emulsifying properties of MRPs depend on the degree of the glycation of the proteins (Li et al., 2009).

Cantonese sausage is one of the most famous Chinese-style semi-dry sausages. It has gained much popularity over the world due to its unique qualities (texture, flavour and taste). Since Ruckdeschel in 1914 reported aroma generation by Maillard pathways, the food industry has patented flavour formation processes from the heated aqueous mixtures of amino acids and reducing sugars. MRPs could be added to Cantonese sausage as flavour enhancers to improve their sensory quality. Hydrolysate from MDCR can be used as the potential source of proteins or peptides for Maillard reactions in the presence of sugars. However, the information regarding the MRPs prepared using MDCR hydrolysates and their application is still limited. Therefore, the objectives of this work were to investigate the MRPs derived from MDCR hydrolysates and to determine the antioxidant, textural and sensory properties of Cantonese sausage in the presence of MRPs.

2. Materials and methods

2.1. Preparation of MDCR hydrolysates

Five hundred grams of MDCR (supplied from Guangdong H-BIO Biotechnology Co., Ltd., Guangzhou, China, 14.80% of protein content)

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were added to 1.5 L of water and held at 55 °C in a water bath. The MDCR/water mixture was allowed to reach a temperature of 55 °C. Pancreatin (activity of 4.0 units/mg solid, purchased from Nanning Pangbo Biological Engineering Co., Ltd., Nanning, China) was added to the slurry with an enzyme/MDCR ratio of 1.5 mg/g MDCR. The slurry was continuously stirred with a mechanical stirrer for 12 h. Then it was heated in boiling water for 10 min to inactivate the proteases. The hydrolysate was centrifuged in a GL-21 M refrigerated centrifuge (Xiangyi Instrument Co. Ltd., Changsha, China) at 5000 *g* for 20 min and the supernatants were collected for further use.

2.2. Analysis of molecular weight and amino acid composition of MDCR Hydrolysates

The molecular weight of hydrolysate was determined by gel permeation chromatography according to the method of Sun et al. (2009) Free amino acids of hydrolysate were determined by a high performance liquid chromatography equipped with a PICO.TAG column (Waters, Milford, MA, USA). Amino acid composition of hydrolysate was determined according to the method of Bidlingmeyer, Cohen, Tarvin and Frost (1987) with a slight modification. The amino acid composition of peptides was determined after hydrolysis at 110 °C for 24 h with 6 M hydrochloric acid prior to the derivatization with phenyl isothiocyanate. L-alanine, L-arginine, L-aspartic acid, L-cystine, L-glutamic acid, glycine, L-histidine, L-isoleucine, L-leucine, L-lysine, L-methionine, L-phenylalanine, L-proline, L-serine, L-threonine, L-tyrosine, L-valine and ammonium chloride were used as standards.

2.3. Preparation of MRPs

MRPs were prepared according to the following formulation: Hydrolysate (solid content: 20%, 100 g), glucose (4.0 g), xylose (5.0 g), vitamin B1 (0.5 g) and cysteamine hydrochloride (1.0 g). They were mixed together and heated for 60 min at 90, 100, 110 and 120 °C to obtain MRPs, namely M1, M2, M3 and M4, respectively. The MRPs were cooled immediately by ice water and kept at 4 °C for further use.

2.4. Measurement of UV-absorbance and browning

The appearance of pre-melanoidins and the formation of melanoidins were monitored by the absorbance of diluted MRP solutions at 420 nm (Wijewickreme, Kitts, & Durance, 1997). Absorbance at 294 nm was used to determine the intermediates of the Maillard reaction (Ajandouz, Tchiakpe, Ore, Benajiba, & Puigserver, 2001). The UV-absorbance and browning of MRPs were measured according to the method of Ajandouz et al. (2001). Appropriate dilution (150-fold dilution) was made using distilled water and the absorbance was measured at 294 and 420 nm by a spectrophotometer (UV2100, Unico Instrument Co., Ltd., Shanghai, China) for determining UV-absorbance and browning intensity, respectively.

2.5. Analysis of DPPH radical scavenging activity and reducing power

The DPPH radical scavenging activity was measured according to the method of Shimada, Fujikawa, Yahara and Nakamura (1992) with some modifications. Two milliliters of MRP (150-fold dilution) were added into 2 ml of 0.2 mM DPPH in methanol. The reaction mixture was incubated for 30 min in dark at room temperature. The absorbance of the resulting solution was measured at 517 nm by a spectrophotometer (UV2100, Unico Instrument Co., Ltd., Shanghai, China). A low absorbance of the reaction mixture indicates a high free radical scavenging activity. The scavenging activity was calculated using the following equation:

$$\text{Scavenging activity } (\%) = 100 \times \left[1-\left(A_{\text{control}}-A_{\text{sample}}\right) / A_{\text{blank}}\right]$$

where the A_{blank} is the value of 2 mL of 95% ethanol mixed with DPPH solution, the A_{sample} is the value of 2 mL of sample solution mixed with DPPH solution, and the A_{control} is the value of 2 mL of sample solution mixed with 2 mL of 95% ethanol.

The reducing power of MRP was determined according to the method of Oyaizu (1986) with a slight modification. Two milliliters of MRP (150-fold dilution) was mixed with 2 ml of 0.2 M sodium phosphate buffer (pH 6.6) and 2 ml of 1% potassium ferricyanide ($K_3Fe(CN_6)$). The reaction mixture was incubated in a water bath at 50 °C for 20 min, followed by addition of 1 ml of 10% trichloroacetic acid. The mixtures were then centrifuged at 1000 *g* by a GL-21 M centrifuge (Xiangyi Centrifuge Instrument Co., Ltd., Changsha, China) for 10 min at 25 °C. The supernatant obtained (2 ml) was treated with 2 ml of distilled water and 200 μl of 0.1% (w/w) $FeCl_3$. The absorbance of the reaction mixture was measured at 700 nm with a spectrophotometer (UV2100, Unico Instrument Co., Ltd., Shanghai, China). Increasing absorbance of the reaction mixture indicates the increase of reducing power.

2.6. Measurement of the surface area weighted diameter and the volume weighted diameter of MRPs

The surface area weighted diameter ($d_{3,2}$, μm) and the volume weighted diameter ($d_{4,3}$, μm) of MRPs were measured by an integrated-laser light scattering instrument (Mastersizer 2000, Malvern Instruments Co. Ltd., Worcestershire, UK). Relative refractive index and absorption were set as 1.414 and 0.001, respectively. The results were analysed using Malvern Mastersizer software (version 5.12c Malvern Instruments Co. Ltd., Worcestershire, UK).

2.7. Cantonese sausage preparation

Lean pork and back fat were obtained from local slaughterhouse. The subcutaneous fat of the lean pork was removed and ground through a 5-mm plate. The back fat was diced into 4 mm cubes. Cantonese sausages were produced in 8 kg batch for each treatment. Cantonese sausage was prepared according to the following formulation: Lean pork (70 g), back fat (30 g), salt (3.5 g), sugar (12 g), wine (4 g), sodium nitrite (0.02 g), water (20 g) and MRP (3.0 g). They were mixed together and stuffed into natural casings with a diameter of 37 mm and oven-dried for 3 h at 50 °C, followed by a reduction of temperature (from 50 °C to 45 °C), then oven-dried for 69 h. Processing yield of Cantonese sausage was about 64–66%. Samples were vacuum packed and stored at room temperature (20 ± 3 °C) in a temperature-controlled chamber for 30 days. Samples were periodically taken at 0th, 5th, 10th, 15th, 20th and 30th days for analyses.

2.8. Moisture content and water activity analysis

Moisture content (%, w/w) was determined in accordance with the method of Johansson, Berdagué, Larsson, Tran and Borch (1994). Water activity was determined using an AquaLab Water Activity Meter (Series 3TE, Decagon Devices, Inc., Pullman, WA, USA). The instrument was calibrated using a set of Aqua Lab salt solutions.

2.9. Lipolysis and lipid oxidation analysis

Total free fatty acids (FFA) content was determined according to Lee and Kunz (2005) for assessing lipolysis of Cantonese sausage. Lipid oxidation was evaluated by peroxide value. Peroxide value was determined after extraction of lipids in accordance with the method reported by Bligh and Dyer (1959).