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Effects of high pressure processing on the quality of pickled radish during refrigerated storage

Rui Bao [a], AiPing Fan [a,b], Xiaosong Hu [a], XiaoJun Liao [a], Fang Chen [a,*]

[a] College of Food Science and Nutritional Engineering, National Engineering Research Centre for Fruits and Vegetables Processing, Key Laboratory of Fruits and Vegetables Processing, Ministry of Agriculture, Engineering Research Centre for Fruits and Vegetables Processing, Ministry of Education, China Agricultural University, Beijing 100083, China
[b] College of Science, Honghe University, Mengzi City, Yunnan Province 661199, China

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ABSTRACT

The objective of this study is to investigate effects of high pressure processing (HPP) on the organoleptic properties of pickled radish during refrigerated storage. Under the HPP treatment at 550 MPa/5 min, total plate count (TPC) decreased by 5.57 $\log_{10}$ CFU/mL, and yeasts and molds (Y&M) were totally inactivated. There is no significant difference in the microbiological index between HPP and thermal processing (TP) at 80 °C/20 min and both samples showed microbiologically safe during 60-day storage at 4 °C (TPC < 2.4 $\log_{10}$ CFU/mL). HPP showed significant impact on pH, hardness and color of pickled radish, whereas had less microstructural damage of pickled radish tissues. In comparison with TP-treated pickled radish the flavor of HPP-treated pickled radish was more preferable. Since HPP increased the abundance of linalool, citronellol and citral and reduced the abundance of sulfide and terpinolene, resulting in the increase of sweetness and the decrease of stimulating flavor.

Industrial relevance: This study was intended to develop better quality and more stable pickled radish without preservative, which is not available on the market now. There is little knowledge on the influence of HPP on the quality of pickles, such as color, texture and flavor. In this study, HPP showed significant impact on pH, hardness and color of pickled radish, whereas had less microstructural damage of pickled radish tissues. HPP treatment could be applied for the inactivation of microorganism, and they were microbiologically safe (TPC < 2.4 $\log_{10}$ CFU/mL, Y&M were not detected) during 90-day storage at 4 °C. In comparison with TP-treated pickled radish the flavor of HPP-treated pickled radish was more preferable. This study provided a comprehensive technical support for the application of HPP in pickles processing.

1. Introduction

Pickles, one of the typical representatives of Chinese traditional fermented foods, are widely consumed in China. Its history can be traced back to the Shang Dynasty (BC1556–1046) (Rao et al., 2013). A range of vegetables can be used as the basic raw materials of pickles, such as radish, cabbage, carrot, cowpea, cucumber, and so on. Usually, pickles are soaked in low salt brine added with a certain amounts of spices, such as garlic, Chinese prickly ash and ginger for about 7 days. The cured pickles have unique flavor due to lactic acid fermented. It also presents crispy texture and contains abundant nutrients such as vitamins, minerals and dietary fiber. However, the quality of pickles is easily to become excessive acidification, rotten and brown if it is not pasteurized or sterilized. Thermal processing (TP) could result in the off-flavor formation, texture softening, browning and loss of vitamins (Awuah, Ramaswamy, & Economides, 2007). The application of preservatives increases the consumers concern about food safety, although it is useful to inhibit the survival of microorganism and maintain the quality of pickles.

High pressure processing (HPP) is an environmentally friendly technology that uses intense hydrostatic pressure to inactivate and destroy harmful microorganism in foods. HPP could maintain nutritional value and sensory properties of foods (Oey, Van der Plancken, Van Loey, & Hendrickx, 2008). Recently, HPP has been applied commercially for the pasteurization of a whole range of food products, such as fruit juices, guacamole, oysters and ham (Matser, Krebbers, van den Berg, & Bartels, 2004). Moreover, the pasteurization of fermented vegetables using HPP has been reported in several studies. Kuribayashi, Ohsawa, Takanami, and Kurokouchi (1996) found that treatment under 400 MPa for 10 min was effective to inactivate microorganisms and increased the preservation period of Nozawana-zuke without loss of fresh flavor, texture, and green color, in comparison with conventional heat sterilization. Peñasa, Frias, Gomez, and Vidal-Valverde (2010) evaluated the impact of HPP on the microbial quality of sauerkraut during refrigerated storage for 3 months, HPP led to a reduction of 4–5 $\log_{10}$ CFU/g in microbial counts. Li et al. (2010) showed similar results in microorganism on

* Corresponding author at: College of Food Science and Nutritional Engineering, China Agricultural University, No. 17, Qinghua East Road, Haidian District, Beijing 100083, China.
E-mail address: chenfangch@sina.com (F. Chen).

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sour Chinese cabbage. Moreover, Sohn and Lee, (1998) suggested that HPP at above 400 MPa prevented excessive acidification and softening of kimchi.

Pickled radish, a kind of Chinese traditional pickles, differs from sauerkraut, Nozawana-zuke and kimchi in raw materials, production methods and recipes. Kimchi is made by lacto-fermentation. Cabbage, the raw material of kimchi, is soaked in salty brine that kills off harmful bacteria. Pack the cabbage mixed with a seasoned paste of red pepper, garlic, ginger and sugar into the jar, pressing down on it until the brine rises to cover the cabbage at room temperature for about 5 days. Li, Zhao, Chen, Lin, and Pu (2012), applied HPP for the inactivation of microorganism of pickled cowpea, and proposed *B. pumilus* as indicator bacteria for HPP treatment. However, there is little knowledge on the influence of HPP on the quality of pickles, such as color, texture and flavor. The aim of the present study was to investigate the effects of HPP on the inactivation of microorganism and quality of pickled radish during storage at 4 °C for 90 days. This study would provide comprehensive technical support for the application of HPP in fermented vegetables (Fig. 1).

2. Materials and methods

2.1. Preparation of pickled radish

Fresh white radish, red cluster pepper, garlic, ginger and pickled ash were purchased at a local market (Beijing, China). The inedible parts were removed and edible parts were clean, then radishes are cut into 1.5 × 1.5 × 5.0 cm strip, and other raw materials were chopped. The ingredients of pickled radish was as follows (w/w): 60% radish, 1% red cluster pepper, 1% garlic, 0.8% ginger, 0.2% Chinese prickly ash, 2% Salt, 35% cold boiled water. All raw materials were put into a fermentation jar added and mixed well. The jar was capped and sealed with water to avoid contact with air. The radish was fermented at 20 °C for 6 days. An aliquot of pickled radish (80.0 g ± 0.1 g) were packed using vacuum-packing machine (DZQ400/500/600, Rishang Co., Ltd., Beijing, China) in a clear nylon/polyethylene retort pouch.

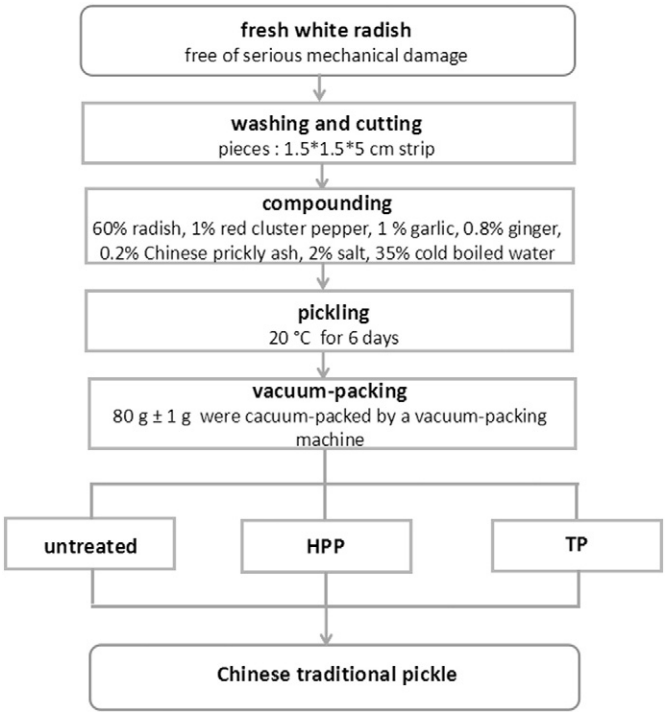

Fig. 1. Flow chart of standard pickled radish production.

2.2. HPP treatments and TP treatment

HPP treatment was carried out using a hydrostatic pressurization unit (HPP-750, Baotou Kefa Co., Ltd., Inner Mongolia, China) with a capacity of 7.0 L. Distilled water was used as the pressure-transmitting fluid. The pressurization was about 120 MPa/min and the pressure release was immediate (<3 s). The treatment time did not include the pressure increase and release time. The pickled radish was placed in the vessel and treated at 300, 400, 500, 550 MPa for 5 min, respectively. The experiment was carried out at room temperature.

TP was carried out in a thermostatic bath (LY-9A, Qingyuan Science & Technology Development Co., Ltd., Beijing, China) at 80 °C for 20 min, and then samples were immediately cooled to room temperature by tap water.

All treated samples were stored at 4 °C and were taken to determine the sensory, chemical, microbiological quality at 0, 7, 15, 30, 45, 60 and 90 days during storage, respectively.

2.3. Microbiological analysis

The total plate count (TPC) method was used to count the viable natural microorganisms. Each sample (10.0 g) was diced and put into a triangular flask filled with 90.0 mL sterile 0.85% NaCl solution and a few beads, then the sample was serially diluted with sterile 0.85% NaCl solution and 1.0 mL of diluted samples was placed into duplicated plates of nutrient agar. The nutrient agar (Beijing Land Bridge Technology Co. Ltd., Beijing, China) was used for detecting TPC after incubation at 37 °C for 48 ± 2 h. Rose Bengal agar (RBA, Beijing Land Bridge Technology Co. Ltd., Beijing, China) was used for detecting the viable Y&M, and the plates were incubated at 27 °C for 72 to 120 h.

2.4. pH determination

The pH was measured at 25 °C using Thermo Orion 555A pH meter (Thermo Fisher Scientific Inc., MA, USA). All pickled radish and solution in pouch were taken out and homogenized (JYL-B060 homogenizer, Joyong Co., Ltd., China). The pH of mixture was measured with a pH meter (Thermo Orion Model 555A, MA, USA).

2.5. Color measurement

Color assessment was conducted at 25 ± 1 °C using a color measurement spectrophotometer (HunterLab ColorQuest XE, Hunter Associates Laboratory, Inc., Virginia, USA) in the reflectance mode immediately after opening of the plastic bags. A white reference plate, a D65 illuminant and a viewing angle of 0° were used. Color was recorded by using the CIE-L, a, b uniform color space. The scale range of a values from negative (green) to positive (red), and the scale range of b values from negative (blue) to positive (yellow). A numerical total color differences (ΔE) was calculated using the following equations, where L_0, a_0 and b_0 were the control values for untreated samples:

$$\Delta E = \left[(L-L_0)^2 + (a-a_0)^2 + (b-b_0)^2\right]^{1/2} \quad (1)$$

2.6. Texture measurement

Texture measurements were performed with a TAXT2i texture analyzer (Stable Micro Systems, Surrey, England) according to Dong et al. (2013) with some modifications. The compression force at 50% strain was obtained by using a cylindrical flat-probe (50 mm diameter; aluminum). The samples, 1.5 cm × 1.5 cm × 0.5 cm, were placed on the platform as an upright cylinder and measured with a 250 N cell at a deformation rate of 1 mm/s. The hardness of the samples was defined as the peak force at 50% strain.