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Effects of gamma irradiation on microbial safety and quality of stir fry chicken dices with hot chili during storage

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HIGHLIGHTS

- Microbial safety and sensory quality of the FCC are ensured by gamma irradiation.
- No viable cells in the irradiated FCC are detected during one year storage.
- Sensory quality of the irradiated FCC is not changed during one year storage.
- Protein content of the FCC is not affected by irradiation during one year storage.

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ABSTRACT

The purpose of this study was to investigate effects of irradiation with different doses on microbial safety, sensory quality and protein content of ready-to-eat stir fry chicken dices with hot chili (FCC) during one year storage. Fresh chicken meat was cut into small dices and fried at approximately 180 °C for 10 min for preparation of FCC samples. The samples were vacuum-packaged and gamma irradiated at 10, 20, 30 and 40 kGy. The results suggest that irradiation with the doses of 10 and 20 kGy could ensure microbiological safety of the samples without deterioration of sensory quality. Microbial counts, sensory qualities and protein contents of the samples were investigated during one year storage. No viable cells were observed and the samples were completely sterilized. Sensory qualities showed no significant difference after irradiated at the doses of 10 and 20 kGy during the storage period. Protein contents were also not affected by irradiation at the same doses. Our results indicate that gamma irradiation of 10 and 20 kGy are effective to maintain shelf stability of ready-to-eat FCC products with microbial safety, sensory quality and nutritional value.

1. Introduction

Stir fry chicken dices with hot chili (FCC) is a very popular chicken-based, Szechuan cuisine in China. It is usually composed of fried diced chicken and dry chili sections with bright golden and red colors, making this dish spicier and more attractive. FCC has been considered as a healthy dish for it mainly consists of low-fat, low-cholesterol and high-protein chicken meat. It tastes hot and crisp outside, tender and fresh inside, and becomes a national favorite on the basis of consumer preference. Due to rapid industrialization, FCC is even being developed as a space food for Chinese astronauts and ready-to-cook/ready-to-eat food for commercial application under special situations.

However, some ingredients contained in the dish, such as raw chicken meat and spices, may introduce potential food-spoilage microorganisms and pose health risks to humans (Beuchat, 1996; Lee et al., 2009). Farag et al. (1995) reported that spices like dry chili, which is a major seasonings in FCC, may initially contain bacterial at a level of $10^5 \sim 10^8$ colony forming units (CFU)/g. Pathogenic bacteria, such as *Campylobacter*, *Salmonella*, *Escherichia coli* and *Listeria* are found in the intestinal tracts of food-producing animals (Lewis et al., 2002). Consequently, FCC has a short shelf life and easily spoils in few days, which prevents the commercial production of FCC products. Therefore a process is needed to

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control microbial growth and ensure the long shelf life and good sensory quality of FCC during long term storage.

Conventional thermal treatment is usually applied for sterilization of commercialized food products in order to meet the national food hygienic standards. However, the conventional thermal treatment may induce adverse effects on the flavor, color and texture of FCC products, resulting in a lack of consumer interest. Also, heat treatment is not an efficient method to remove spoilage bacteria in FCC products for high contamination of spoilage bacteria from raw chicken meat and seasonings (Park et al., 2010; Nijhuis et al., 1998).

Gamma irradiation has been considered as a promising technology for reducing pathogen-induced food poisoning and extending shelf life without compromising nutritional properties of food products (Farkas, 2006). Irradiation technology has been widely applied in not only various food and agricultural products, but also health care products, such as drugs, medical devices and cosmetics (Farkas, 1998; International Atomic Energy Agency (IAEA), 2008). Compared with thermal treatment, irradiation has relative economical and nutritional advantages (Shin et al., 2013). No harmful substances are generated and remained in products after irradiation (Swallow, 1991; Diehl, 2001). According to the conclusions drawn by a Joint FAO/IAEA/WHO Study Group in 1997, food irradiated at any dose is both safe to consume and nutritionally adequate (WHO, 1999). Nowadays, about 60 countries granted national clearances for food irradiation and over 30 of these countries, such as China, Korea, Pakistan, South Africa and the USA etc., are actually applying the technology for commercial purposes including hygienic quality improvement, enhancing shelf stability, delaying ripening and quarantine on imported food and agricultural products (Ahn et al., 2013; Bustos-Griffin et al., 2012).

In the present study, the ready-to-eat FCC product was prepared and different doses of irradiation were applied to the product and the effects of gamma irradiation on microbial safety, sensory quality and protein content of the product were also investigated during storage for one year at 25 °C.

2. Materials and methods

2.1. Sample preparation

Raw boneless chicken thigh and seasonings were purchased from a local supermarket (Ito-Yokado, Chengdu, China). The amounts of ingredients per 1000 g raw chicken thigh meat used were dry chili (60 g), Chinese red pepper (12 g), soy sauce (8 g), ginger (10 g), sugar (5 g), salt (6 g), sweet potato flour (15 g), cooking wine (8 g), dry sesame (5 g) and green onion (12 g). Chicken thigh meat was cut into small dices (1.5 cm × 1.5 cm) and mixed with soy sauce, salt, sweet potato flour and cooking wine. The chicken dices were fried in a wok with rapeseed oil (approximately 180 °C) for 10 min and then stir-fried with dry chili, Chinese red pepper and ginger for 3 min. After sugar, dry sesame and green onion added and mixed, the sample was cooled to room temperature. Approximately 30 g of the sample was vacuum-packaged in an aluminum-laminated polyethylene bag using a packaging machine (DZ-500/2ES, Hualian Machinery Group, Wenzhou, China) and gamma irradiated.

2.2. Gamma irradiation

Samples were irradiated using a gamma irradiator (FJX-432 G2, Bine High-Tec Co. Ltd., Beijing, China) with cobalt-60 source (Nordion Inc., Ottawa, ON Canada) at Sichuan Institute of Atomic Energy (Chengdu, China). The source strength was approximately 3.33×10^{16} Bq with a dose rate of 35 Gy/min and the actual doses were within 1.5% of the target dose. The absorbed dose was monitored with $Ag_2Cr_2O_7$ dosimeters. Irradiation process was carried out at 25.0 ± 1.0 °C. To investigate the effects of γ-irradiation on microbial and sensory quality of the stir fry chicken dices with hot chili, the samples were irradiated at 10, 20, 30, 40 kGy and then stored at 4 °C before analysis. The analysis was conducted within 12 h after irradiation. Besides, the irradiated samples (10 and 20 kGy) were stored at 25.0 °C for one year and periodically analyzed for microbial safety, protein content and sensory quality.

2.3. Microbial analysis

A portion (25 g) of the sample was aseptically placed into a sterile bag (30 × 19 cm, BiLon Lab Equipment Co., Ltd., Wuxi, China) containing 225 mL sterilized 0.85% physiological saline and homogenized in a masticator (Bilon-08, Bilon Lab Equipment Co., Ltd., Wuxi, China) for 1 min at max speed. Homogenates were serially diluted with 0.85% physiological saline. A 1 mL diluent was placed on Petri plate and 15 mL of medium was then poured and mixed with the diluent. The following media were used for culturing: plate count agar (Aoboxing Bio-tech Co., Ltd., Beijing, China) for total aerobic bacteria, *Bacillus* Megatherium medium (Hope Bio-Technology Co. Ltd., Qingdao, China) for *Bacillus* spp., Rose Bengal medium (Aoboxing Bio-tech Co., Ltd., Beijing, China) for yeast and molds, Baird-Parker medium (Huankai Microbial Sci. & Tech Co., Ltd., Guangzhou, China) for coagulase positive Staphylococci, eosine methylene blue agar (Huankai Microbial Sci. & Tech Co., Ltd., Guangzhou, China) for *Escherichia coli*, buffered peptone water, Rappaport-Vassiliadis Salmonella enrichment broth and Salmonella chromogenic medium (Hope Bio-Technology Co., Ltd., Qingdao, China) for Salmonella. After media solidified, the plates were incubated for bacterial growth at 36.0 ± 1.0 °C for 48 h and 28.0 ± 1.0 °C for fungal growth for 5 days under aerobic conditions. The sample was cultured in triplicate on each medium and the colonies on the plates were manually counted at a dilution of 30–300 CFU per plate.

2.4. Sensory evaluation

Sensory characteristics of the samples were evaluated by 7 trained panelists. Each member evaluated the sample independently for its color, flavor, texture and overall acceptance using a 9-point hedonic scale ranging from 1 (extremely dislike or weak) to 9 (extremely like or strong) (Yoon et al., 2012). Water was provided to wash the oral cavity between each test.

2.5. Protein content

Protein content of the sample was measured using a VELP UDK149 automatic distillation unit and DKL heating digester (VELP Scientifica, Usmate, Italy) following the method described by Thiex et al. (2002). The protein content was calculated as $K_jN \times 6.25$.

2.6. Statistical analysis

All the experiments were performed in triplicate. Microbial count data (CFU/g) was transformed to $\log_{10}$ scale prior to statistical analysis. The mean values of microbial load, sensory evaluation and protein content were compared for significant differences using Duncan's multiple range tests by PASW 18.0 (SPSS Inc., Chicago, IL, USA). Statistical significant was set at $p < 0.05$.