

Effect of Irradiated Red Pepper Powder on *Kimchi* Quality during Fermentation

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Abstract

Irradiated red pepper powder (IRPP) was tested for its ability to retard fermentation and to maintain a high quality of *Kimchi* by the reduction of the initial microbial load. *Kimchi* containing IRPP at the doses of 0, 5, 10, 15, or 20 kGy was prepared. Quality indices for *Kimchi* in this study were pH, titratable acidity, reducing sugar content, total microbial count, lactic acid bacterial load, and sensory evaluation. Based on the pH and titratable acidity, the *Kimchi* with IRPP showed a retarded fermentation until 15 days. The number of the total aerobes and lactic acid bacteria of the *Kimchi* with IRPP were lower by about 1 log CFU/mL compared to control at day 0, however, the counts increased to 8.5 log CFU/mL after 10 days, which was similar to the control group. *Kimchi* that was fermented with 5 kGy IRPP was better than control and other treatments in odor and color, whereas the control scored highest in taste. Addition of IRPP showed a limited retardation of *Kimchi* fermentation without other quality deterioration.

Key words: *Kimchi*, irradiated red pepper powder, quality

INTRODUCTION

Kimchi, the most popular side dish for Koreans, is a fermented vegetable food. Chinese cabbage and radish are the main ingredients and red pepper powder, garlic, green onion and ginger are generally used as seasonings. There are about one hundred kinds of *Kimchi* (1), but *baechu Kimchi* (Chinese cabbage *Kimchi*) and *Kakdugi* (diced radish *Kimchi*) are the ones most favored in Korea (2). Due to the various seasonings, *Kimchi* has a unique flavor compared to other fermented foods such as pickles and sauerkraut. The role of seasonings is to accelerate fermentation and may be beneficial until the optimum aging period, but the seasonings can also decrease the shelf-life due to the formation of excessive organic acids. Among several standards for measuring the optimum aging, pH and titratable acidity of *Kimchi* are generally accepted criteria (3,4). Based on this criteria, pH 4.2 and 0.6~0.8% titratable acidity are suitable end points for the optimum-aging period of *Kimchi* (3). The quality of *Kimchi* steeply decreases due to the development of a sour taste and softness of the Chinese cabbage thereafter. Many studies have evaluated the effect of gamma irradiation (5,6), addition of salts (7), and natural preservatives (8,9) on prolonging the shelf life of *Kimchi*. Park et al. (10) suggested that initial microbial load in seasonings should be reduced to enhance the keeping quality

of *Kimchi*. Red pepper powder (*Capsicum annum* L.) showed a higher bacterial count than the other seasonings; specially coliform and *Lactobacillus* count (11).

In this study, red pepper powder was gamma-irradiated to reduce initial microbial load. Extension of the optimum aging period was attempted by irradiating the red pepper powder used for *Kimchi* preparation.

MATERIALS AND METHODS

Materials

Chinese cabbage, garlic, green onion, ginger, fermented anchovy juice and salt were purchased on the day of *Kimchi* preparation at a local market in Masan. Red pepper powder was aerobic-packaged in oxygen permeable plastic bags and irradiated using a cobalt-60 irradiator (Point source, AECL, IR-79, Nordion Int'l. Co., Ottawa, Ont., Canada). To achieve a uniform irradiation dose, the samples were placed on motor rotors (Irradiation rotation plate, Eastern Engineering Co., Daejeon, Korea) with a rotor speed of 2 rpm during irradiation. The source strength was about 100 KCi with a dose rate of 5 kGy/h at $12 \pm 0.5^\circ\text{C}$. True absorbed doses were measured by a 5 mm diameter alanine dosimeters (Bruker Instruments, Rheinstetten, Germany), and the free radical signal was measured using an EMS 104 EPR Analyzer (Bruker BioSpin GmbH, Rheinstetten, Germany) The

irradiation doses in this study were 0, 5, 10, 15, and 20 KGy of the target dose. After irradiation, the irradiated red pepper powder (IRPP) was kept at 10°C till use.

Kimchi preparation

Halved Chinese cabbage was soaked in a 10% salt solution about 12 hrs, and then washed with tap water twice and drained for 2 hrs. To measure the salt concentration of Chinese cabbage, about 250 g of it was sampled, blended, and its salt concentration was measured with a salt meter (NS-3P, Merbabu Trading Co., Ltd., Osaka, Japan). Garlic and ginger were peeled, washed and crushed. Green onion was trimmed, washed and transversely cut into 2 mm long pieces. Salted Chinese cabbage was cut into about 4×4 cm pieces and made into *Kimchi* by adding secondary ingredients and IRPP. The amount of seasonings was 3 g IRPP, 2 g crushed garlic, 1.5 g green onion, 0.75 g fermented anchovy juice, and 0.5 g ginger per 100 g salted Chinese cabbage. The mixture was thoroughly mixed and 300 g packed into plastic bottles (inner diameter 9 cm, inner height 8 cm), and fermented at 10°C for 30 days. Three replicates were prepared for each treatment.

Microbial analyses

Kimchi juice was filtered through a sterile thin cloth, and diluted as needed in 0.1% peptone water. The diluted solution (0.1 mL) was spread onto plate count agar (Difco Laboratories, Franklin Lakes, NJ, USA) and MRS agar (Difco) with a 0.02% sodium azide. Plates were counted after 72 and 48 hrs of incubation at 30°C and 37°C, respectively (11,12). Microbial counts were expressed as colony-forming unit (CFU) per mL sample.

Chemical analyses

The samples in the plastic bottles were poured into a juicer (GP-1619, GreenPower Co., Seoul, Korea), and filtered with a thin cloth to obtain *Kimchi* filtrate for chemical analyses. A 10 mL of *Kimchi* filtrate was tested for pH (pH meter 220, Corning Co., Corning, NY, USA), and titratable acidity determined by titrating with 0.1 N NaOH to pH 8.3. *Kimchi* filtrate was diluted as required, and a 3 mL was taken to measure reducing sugar content by the dinitrosalicylic acid method (13).

Sensory evaluation of *Kimchi*

After fermentation for 10-day at 10°C *Kimchi* had reached near optimal aging and used as samples for sensory evaluation. Ten trained panelists scored the odor, color and taste of *Kimchi* on a 5 points hedonic scaling method. Five point was regarded as excellent and 1 point as extremely poor. Significant differences between samples were assessed by Duncan's multiple range test, and

the level of significance was established at $p < 0.05$. All statistical analyses were performed with SAS software (14).

RESULTS AND DISCUSSION

Changes in pH and titratable acidity

The pH of *Kimchi* decreased during fermentation (Fig. 1). The steep decrease was revealed between days 2~10 of fermentation, then remained stable around pH 3.7~3.9 thereafter. The pHs of *Kimchi* with non-IRPP and 10 kGy IRPP were 5.76 on the day of preparation, whereas other treatments showed pH 5.92~6.03. *Kimchi* with IRPP maintained a higher pH than that with non-IRPP until 10 days, and that with 20 kGy IRPP showed the highest pH during the entire fermentation period.

Titratable acidity increased throughout fermentation with a steep increase between 5 and 10 days (Fig. 2), while pHs of *Kimchi* were nearly same after 10 days (Fig. 1).

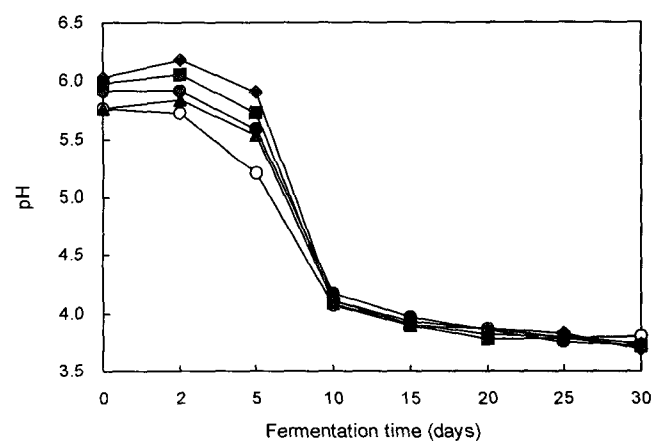


Fig. 1. Changes in pH of *Kimchi* with irradiated red pepper powder during fermentation at 10°C. ○: Control, ●: 5 KGy, ▲: 10 KGy, ■: 15 KGy, ◆: 20 KGy.

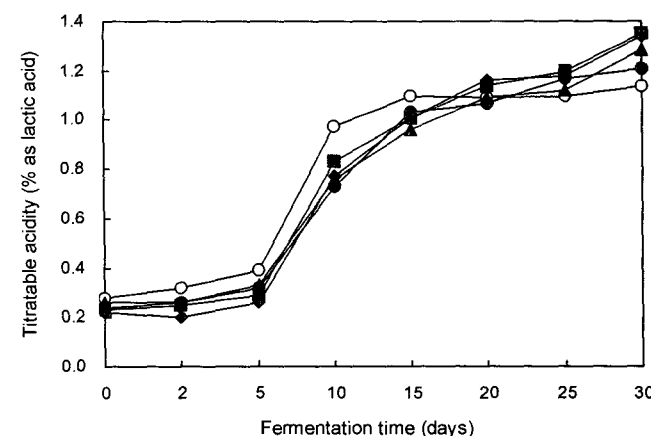


Fig. 2. Changes in titratable acidity of *Kimchi* with irradiated red pepper powder during fermentation at 10°C. ○: Control, ●: 5 KGy, ▲: 10 KGy, ■: 15 KGy, ◆: 20 KGy.

This phenomenon was due to the buffer action of amino acids and minerals in *Kimchi* (4). *Kimchi* containing IRPP maintained a lower titratable acidity until 15 days of fermentation because IRPP contained fewer microorganisms than non-IRPP (Fig. 4). The titratable acidity of a Chinese cabbage *Kimchi* after optimal aging is 0.6~0.8% (5). Based on the results of pH and acidity, the using IRPP for making *Kimchi* can prolong the optimum-aging period by about 2 or 3 days.

Changes in reducing sugar content

Reducing sugar content was generally decreased during fermentation due to the formation of several organic acids by lactic acid bacteria (Fig. 3). *Kimchi* containing IRPP showed a lower initial reducing sugar content than that of the control *Kimchi*. Although there was a report (15) that irradiation of powdered hot pepper paste slightly increased reducing sugars, irradiation may have a different effect on hot red pepper in *Kimchi*. Between the 2nd to 5th day of fermentation, the reducing sugar content was markedly reduced. The most significant difference in reducing sugar content among the treatment groups was observed on day 10 of fermentation with the 20 kGy group showing 23.3 mg/mL sugar content, which was 8.4 mg/mL higher than that of 10 kGy treatment.

Microbial analysis

Kimchi samples that were prepared with IRPP showed about one tenth lower total microbial count on the preparation (Fig. 4). Choi et al. (16) isolated and identified 13 species of molds with $2\sim 3 \times 10^2$ CFU/g and 5 species of bacteria with $3\sim 6 \times 10^7$ CFU/g from red pepper powder sold in Korea, which would be sufficiently destroyed by 2 kGy gamma irradiation. Lee et al. (17) also reported that the red pepper powder was significantly contaminated with bacteria (1.05×10^8 CFU/g) and molds

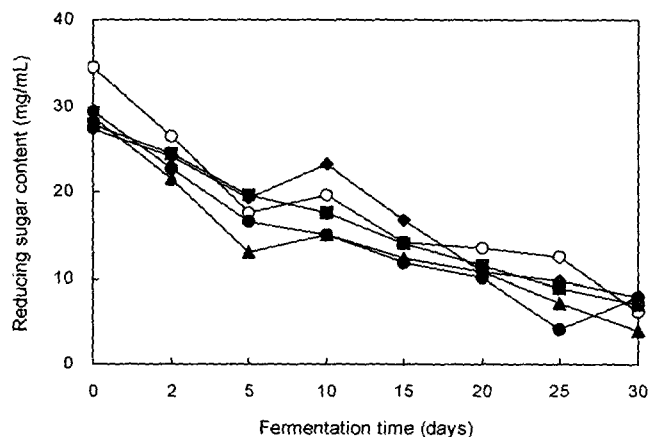


Fig. 3. Changes in reducing sugar content of *Kimchi* with irradiated red pepper powder during fermentation at 10°C. ○: Control, ●: 5 kGy, ▲: 10 kGy, ■: 15 kGy, ◆: 20 kGy.

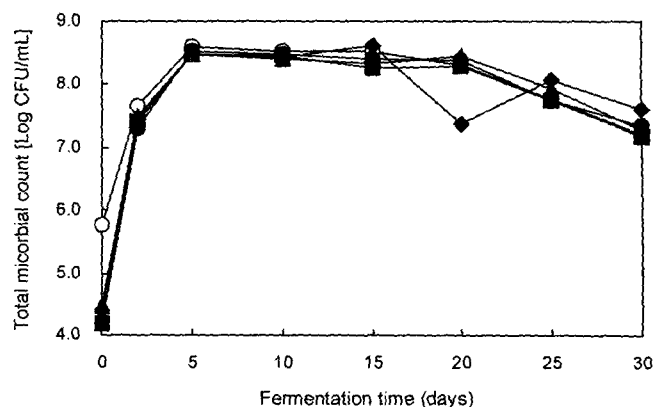


Fig. 4. Changes in total microbial count of *Kimchi* with irradiated red pepper powder during fermentation at 10°C. ○: Control, ●: 5 kGy, ▲: 10 kGy, ■: 15 kGy, ◆: 20 kGy.

(1.86×10^4 CFU/g), and D_{10} value for the mixed microorganisms was 2.1 kGy of gamma irradiation. The contaminated microbial species in hot pepper (18) or red paprika (19) were completely eliminated with irradiation at stronger than 10 kGy.

Lactic acid bacterial load steeply increased after 2 days of fermentation, and *Kimchi* with IRPP showed lower microbial load than control until day 15 (Fig. 5). The microbial load including lactic acid bacteria was sufficiently decreased by irradiation, which was consistent with the higher pH in *Kimchi* with IRPP.

Sensory evaluation

Table 1 shows the results of the sensory evaluation of odor, color, and taste of *Kimchi* fermented at 10°C for 10 days. The treatment group added with 5 kGy IRPP scored higher than control for odor and color, while 20 kGy showed the lowest score. This suggests that high dose irradiation may have an adverse effect on red pepper powder during fermentation. The control *Kimchi* consistently scored higher for taste than *Kimchi* prepared

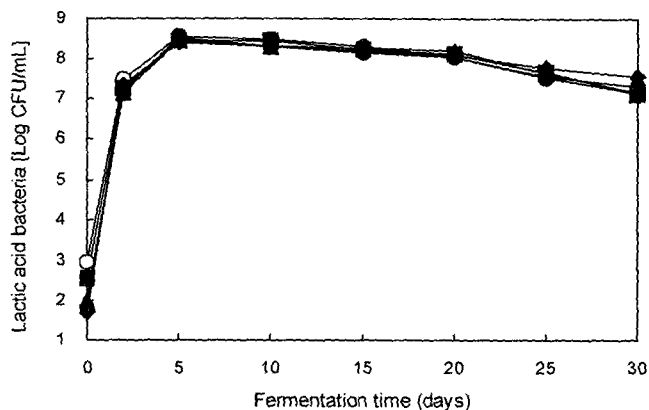


Fig. 5. Changes in lactic acid bacteria of *Kimchi* with irradiated red pepper powder during fermentation at 10°C. ○: Control, ●: 5 kGy, ▲: 10 kGy, ■: 15 kGy, ◆: 20 kGy.

Table 1. Sensory evaluation of *Kimchi* prepared with irradiated red pepper powder and fermented for 10 days at 10°C

Treatment	Quality		
	Odor	Color	Taste
Control	3.14 ^{ab1)}	3.86 ^a	3.86 ^a
5 kGy	3.71 ^a	4.29 ^a	3.43 ^{ab}
10 kGy	3.71 ^a	3.71 ^{ab}	3.43 ^{ab}
15 kGy	3.14 ^{ab}	3.00 ^b	3.00 ^{ab}
20 kGy	2.43 ^b	1.86 ^c	2.29 ^b

¹⁾A 5 point scale was used. Values are means of 10 panelists, different letters in the same column are significantly different at the 0.05 level of significance.

with IRPPs, but there were no significant differences except for the 20 kGy IRPP *Kimchi*.

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