

## Microbial Decontamination of *Angelica gigas* Nakai Using Electron Beam Irradiation

– Research Note –

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### Abstract

This study evaluated the use of electron beam irradiation for decontamination of the Korean medicinal herb, *Angelica gigas* Nakai. Herb samples were irradiated at doses of 2, 8, and 16 kGy, respectively. Populations of microorganisms in *Angelica gigas* Nakai decreased by 2–3 log cycles at 8 kGy irradiation. Electron beam irradiation caused negligible changes in Hunter color L, a, and b values. Sensory evaluations of *Angelica gigas* Nakai confirmed that irradiation caused no significant changes in the organoleptic properties of the samples. These results suggest that electron beam-irradiated herbs retain a better microbial safety and sensory qualities, compared with the non-irradiated.

**Key words:** electron beam, irradiation, *Angelica gigas* Nakai, storage

### INTRODUCTION

Medicinal herbs, a major source of phytochemicals, are widely utilized, and provide an important contribution to health care (1,2). Herbal medicinal products should meet microbial safety standards during storage and marketing. In general, microbiological contamination of medicinal herbs is a serious problem; the conventional methods of decontamination have been fumigation with gaseous ethylene oxide or methyl bromide, but their uses have been prohibited or restricted for health concerns (3).

Food irradiation is a well-established decontamination method, but has not been widely applied to fresh medicinal herbs (4). Food irradiation is recognized as an effective method in providing hygienic quality by reducing quality loss due to microbial spoilage. The two most common types of ionizing radiation are gamma ray and electron beam. Electron beam irradiation has a shorter processing time and does not produce radioactive waste (5). Thus, electron beam as well as gamma irradiation can be applicable to medicinal herbs to achieve microbial decontamination.

Therefore, the objective of this study was to examine the effect of electron beam irradiation on the shelf life, microbial growth, and organoleptic qualities of the Korean medicinal herb, *Angelica gigas* Nakai.

### MATERIALS AND METHODS

#### Materials

*Angelica gigas* Nakai was purchased from a local mar-

ket in Daejeon, Korea.

#### Electron beam irradiation

Electron beam irradiation was performed using an electron-beam accelerator (model ELV-4, 1 MeV, Eb-Tech). Samples (thickness: 0.5 cm) were individually vacuum-packaged in 120 mm × 60 mm low density polyethylene (LDPE) bags. Based on a preliminary experiment, samples were exposed to 3 dose levels of 2, 8, and 16 kGy at 1 MeV and 100 kW. Absorption dose was determined using a cellulose triacetate (CTA) dosimeter.

#### Microbiological analysis

After electron beam irradiation, samples (5 g) were removed from the vacuum package using a sterile scalpel. Samples were placed in 45 mL of 0.1% peptone water in a sterile stomacher bag. Samples were homogenized using a Stomacher (MIX 2, AES Laboratoire, France) for 3 min, filtered through a sterile cheese cloth, and diluted with peptone water for microbial count. Serial dilutions were performed in triplicate on each selective agar plate.

Total bacterial counts were determined by plating the appropriately diluted samples onto plate count agar (PCA, Difco Co., Detroit, MI, USA). Samples were evenly spread on the surface of the plates with a sterile glass rod. Yeast and mold were plated on potato dextrose agar (PDA, Difco Co., Detroit, MI, USA). Both plates were incubated at 37°C for 48 hr. For total coliform counts, Chromogenic *E. coli*/Coliform Medium (EC,

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Oxoid Ltd., Basingstoke, Hants, England) was used, and plates were incubated at 37°C for 24 hr. During storage, changes of residual total bacteria, yeast and mold, and total coliform counts were determined. Each microbial count was the mean of three determinations and microbial counts were expressed as log CFU/g.

#### pH measurement

Samples (5 g) were homogenized in 45 mL distilled water using a grinder (model MCH600SI, Tong Magic Co., Seoul, Korea) for 1 min. Sample solutions were centrifuged for 15 min at 2,000 × g, and the pH was measured using a pH meter (Corning Inc., Corning, NY, USA).

#### Color measurement

Color of samples was analyzed using a colorimeter (CR-300 Minolta Chroma Meter, Minolta Camera Co., Osaka, Japan). Samples were placed on a white standard plate and the Hunter's color values (L, a, b) were measured and total color difference values were expressed as ΔE value. Hunter's L, a, and b values for the standard plate were L=98.34, a=-0.03, b=1.62, respectively. Five measurements were taken at different locations on each sample.

#### Sensory evaluation

Samples were analyzed for their color, odor, and overall acceptability by 10 trained panelists. Sensory qualities of samples were evaluated using a five point scoring method. The sensory scores were 5: very good, 4: good, 3: fair, 2: poor, 1: very poor.

#### Statistical analysis

Analysis of variance and Duncan's multiple range tests with significance at  $p < 0.05$  were performed to analyze the results statistically using a SAS program.

## RESULTS AND DISCUSSION

#### Microbiological analysis

Initial populations of total bacteria, yeast and mold, and total coliforms of *Angelica gigas* Nakai were 3.0, 2.5, and 1.0 log CFU/g, respectively. Compared to other studies using different medicinal herbs (2,3), our results are in good agreement in terms of initial microbial load of herbs, showing that most medicinal herbs need better hygienic quality. Therefore, these results suggest a need of sterilization to reduce bacteria counts of *Angelica gigas* Nakai to acceptable levels. Also, according to the domestic standard for food manufacturing, coliforms should be absent.

Electron beam irradiation above 2 kGy completely eliminated coliform bacteria (data not shown), and pop-

ulations of both total bacteria and yeast and mold were significantly reduced (Fig. 1) in a dose-dependant manner. Total bacteria as well as yeast and mold in samples were eliminated by irradiation at 16 kGy. Populations of total bacteria treated with electron beam at 8 kGy were reduced to 1.46 log CFU/g, compared to 3.0 log CFU/g for the non-irradiated sample. Yeast and mold, following irradiation at 8 kGy, decreased from 2.51 log CFU/g to 1.0 log CFU/g. During storage of herbs, populations of total bacteria for the non-irradiated increased to 4.9 log CFU/g after 3 months, while the irradiated herb at 8 kGy reached 1.64 log CFU/g. For populations of yeast and mold, the irradiated herb at 8 kGy had 1.2 log CFU/g, compared to 3.92 log CFU/g.

Only a few studies have reported the effects of ionizing irradiation on medicinal herbs. Soriani et al. (2) reported that gamma irradiation of *Ginkgo biloba* at 11.4

A

B

**Fig. 1.** Effect of electron beam irradiation on microbial growth in *Angelica gigas* Nakai at various irradiation doses. Bars represent standard error. ●: 0 kGy, △: 2 kGy, ■: 8 kGy, ○: 16 kGy. A: total aerobic bacteria, B: yeast and mold.

kGy reduced total bacteria to less than 1 log CFU/g, exhibiting similar results as ours. There was also a report on the effect of electron beam irradiation of *Calendula officinalis* at 10 kGy, resulting in a 2 log cycle reduction in microorganisms (3).

FAO/IAEA/WHO Expert Committee on food irradiation (JECFI) recommends 10 kGy as an upper dose for food irradiation processes, which is considered to be safe, meaning that there is no evidence of toxicity at that dose. In this study, we showed that electron beam irradiation at 8 kGy decreased microorganisms in *Angelica gigas* Nakai during storage up to 3 months by 2~3 log cycles, resulting in microbial safety.

### Change in pH during storage

The pH value, a reliable indicator of food stability, is associated with microbial and chemical reactions that cause food deterioration. Fig. 2 showed that the pH of *Angelica gigas* Nakai treated with electron beam irradiation as well as the control was increased during storage, similarly to another report (6). However, there was no significant difference among the treatments during storage. Initial pH values after treatment of *Angelica gigas* Nakai with irradiation were 5.81, 5.82, 5.83, and 5.88 at 0, 2, 8, 16 kGy, respectively, showing that there was no change among treatments. These results are in good agreement with another study (7) in which electron beam irradiation did not affect the pH of mangoes during storage.

### Color measurement and sensory evaluation

Color of *Angelica gigas* Nakai was determined during storage using a colorimeter, and Hunter's L, a, and b values of samples are shown in Table 1. Hunter L, a, and b values of *Angelica gigas* Nakai treated with electron beam at different doses were not significantly differ-

H  
P

**Fig. 2.** Changes in pH of irradiated *Angelica gigas* Nakai during storage.

Bars represent standard error.

●: 0 kGy, △: 2 kGy, ■: 8 kGy, ○: 16 kGy.

ent during storage. In general, fumigant treatment or gamma irradiation at 7 kGy has been known to decrease the whiteness and increase the yellowness (8). Our results show that electron beam treatment does not cause color change in *Angelica gigas* Nakai, and sensory qualities are observed to be the same among the treatments during storage (Table 2). These results are similar with our previous report (9) where whole black pepper and commercial *Sunsik* were irradiated by electron beam. In summary, electron beam treatment is likely to minimize quality change such as color and flavor, while achieving microbial decontamination.

### ACKNOWLEDGEMENT

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**Table 1.** Changes in Hunter color values of electron beam irradiated *Angelica gigas* Nakai

Color parameter	Storage period (month)	Irradiation dose (kGy)			
		0	2	8	16
L	0	80.50 ± 0.50 <sup>a</sup>	80.44 ± 1.37 <sup>a</sup>	80.97 ± 0.54 <sup>a</sup>	80.90 ± 0.35 <sup>a</sup>
	1	80.50 ± 0.98 <sup>a</sup>	80.88 ± 0.66 <sup>a</sup>	80.17 ± 0.88 <sup>a</sup>	80.37 ± 0.30 <sup>a</sup>
	2	78.70 ± 0.48 <sup>a</sup>	79.75 ± 0.56 <sup>a</sup>	79.54 ± 0.65 <sup>a</sup>	79.80 ± 0.39 <sup>a</sup>
	3	78.63 ± 0.64 <sup>a</sup>	79.09 ± 0.26 <sup>a</sup>	79.90 ± 0.37 <sup>a</sup>	78.86 ± 0.96 <sup>a</sup>
a	0	-0.62 ± 0.69 <sup>a</sup>	-0.62 ± 0.25 <sup>a</sup>	-0.62 ± 0.15 <sup>a</sup>	-0.62 ± 0.15 <sup>a</sup>
	1	-0.62 ± 0.38 <sup>a</sup>	-0.62 ± 0.89 <sup>a</sup>	-0.62 ± 0.50 <sup>a</sup>	-0.62 ± 0.03 <sup>a</sup>
	2	-0.61 ± 0.34 <sup>a</sup>	-0.61 ± 0.09 <sup>a</sup>	-0.62 ± 0.20 <sup>a</sup>	-0.61 ± 0.06 <sup>a</sup>
	3	-0.61 ± 0.05 <sup>a</sup>	-0.61 ± 0.08 <sup>a</sup>	-0.61 ± 0.20 <sup>a</sup>	-0.61 ± 0.41 <sup>a</sup>
b	0	22.87 ± 0.70 <sup>a</sup>	22.95 ± 0.56 <sup>a</sup>	22.83 ± 1.03 <sup>a</sup>	22.84 ± 0.62 <sup>a</sup>
	1	21.86 ± 0.93 <sup>a</sup>	22.18 ± 0.67 <sup>a</sup>	22.73 ± 0.11 <sup>a</sup>	22.82 ± 0.62 <sup>a</sup>
	2	20.58 ± 0.43 <sup>a</sup>	21.18 ± 0.97 <sup>a</sup>	22.44 ± 2.07 <sup>a</sup>	22.40 ± 0.53 <sup>a</sup>
	3	20.91 ± 0.66 <sup>a</sup>	20.27 ± 0.50 <sup>a</sup>	22.27 ± 1.81 <sup>a</sup>	22.46 ± 0.82 <sup>a</sup>

<sup>a</sup>Any means in the same column followed by the same letter are not significantly (p<0.05) different by Duncan's multiple range test.

**Table 2.** Sensory evaluation of electron beam irradiated *Angelica gigas* Nakai during storage

Organoleptic parameter	Irradiation dose (kGy)	Storage period (month)			
		0	1	2	3
Color	0	5.00 ± 0.00 <sup>a</sup>	5.00 ± 0.00 <sup>a</sup>	5.00 ± 0.00 <sup>a</sup>	5.00 ± 0.00 <sup>a</sup>
	2	5.00 ± 0.00 <sup>a</sup>	5.00 ± 0.00 <sup>a</sup>	5.00 ± 0.00 <sup>a</sup>	5.00 ± 0.00 <sup>a</sup>
	8	4.30 ± 0.58 <sup>a</sup>	4.30 ± 0.58 <sup>a</sup>	4.30 ± 0.58 <sup>a</sup>	4.20 ± 0.84 <sup>a</sup>
	16	4.30 ± 0.58 <sup>a</sup>	4.30 ± 0.58 <sup>a</sup>	4.20 ± 0.84 <sup>a</sup>	4.20 ± 0.84 <sup>a</sup>
Odor	0	5.00 ± 0.00 <sup>a</sup>	5.00 ± 0.00 <sup>a</sup>	5.00 ± 0.00 <sup>a</sup>	5.00 ± 0.00 <sup>a</sup>
	2	5.00 ± 0.00 <sup>a</sup>	5.00 ± 0.00 <sup>a</sup>	5.00 ± 0.00 <sup>a</sup>	5.00 ± 0.00 <sup>a</sup>
	8	4.30 ± 0.58 <sup>a</sup>	4.30 ± 0.58 <sup>a</sup>	4.30 ± 0.58 <sup>a</sup>	4.20 ± 0.84 <sup>a</sup>
	16	4.30 ± 0.58 <sup>a</sup>	4.30 ± 0.58 <sup>a</sup>	4.20 ± 0.84 <sup>a</sup>	4.20 ± 0.84 <sup>a</sup>
Overall	0	5.00 ± 0.00 <sup>a</sup>	5.00 ± 0.00 <sup>a</sup>	5.00 ± 0.00 <sup>a</sup>	5.00 ± 0.00 <sup>a</sup>
	2	5.00 ± 0.00 <sup>a</sup>	5.00 ± 0.00 <sup>a</sup>	5.00 ± 0.00 <sup>a</sup>	5.00 ± 0.00 <sup>a</sup>
	8	4.70 ± 0.58 <sup>a</sup>	4.70 ± 0.58 <sup>a</sup>	4.70 ± 0.58 <sup>a</sup>	4.70 ± 0.58 <sup>a</sup>
	16	4.70 ± 0.58 <sup>a</sup>	4.70 ± 0.58 <sup>a</sup>	4.70 ± 0.58 <sup>a</sup>	4.70 ± 0.58 <sup>a</sup>

<sup>a</sup>Any means in the same column followed by the same letter are not significantly ( $p < 0.05$ ) different by Duncan's multiple range test.

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