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Note

Effect of Electron Beam Irradiation on Microbial Growth and Qualities in *Astragalus membranaceus*

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Electron beam irradiation was applied to examine the microbial growth and qualities of vacuum-packaged *Astragalus membranaceus*, a Korean medicinal herb. Samples were irradiated at dose of 2, 4, 8, 12, and 16 kGy, respectively. Microbiological data on *A. membranaceus* showed that populations of total bacteria, yeast and mold, total coliforms were significantly reduced with increase of irradiation dose. Populations of microorganisms in *A. membranaceus* were decreased by 2-3 log cycles at 8 kGy irradiation. Color measurements showed that electron beam treatment caused negligible changes in Hunter color L, a, and b values of *A. membranaceus*. Sensory evaluations showed that there were no significant changes among the samples. These results suggest that electron beam irradiated *A. membranaceus* have better microbial safety and qualities, compared with the non-irradiated control.

Key words: *electron beam, irradiation, Astragalus membranaceus, quality*

Medicinal herbs have been widely utilized for health purpose, and they provide an important contribution to functional food product market as well as pharmaceutical ingredients.[1,2] However, for therapeutic preparation, herbal medicinal products should meet microbial safety during processing and storage. In particular, microbiological contamination of medicinal herbs is a serious problem, and the conventional methods of decontamination such as fumigation with gaseous ethylene oxide or methyl bromide have been prohibited or restricted due to health concern.[3]

Electron beam irradiation is a well-established method for microbial decontamination, but it has received less attention for medicinal herbs.[4] In general, ionizing radiation is recognized as an effective method in providing hygienic quality by reducing quality loss due to microbial spoilage. For food products, there are two types of ionizing radiation; gamma ray and electron beam. Electron beam is generally simpler and cheaper, and also has shorter processing time.[5] Thus, it can be applicable to medicinal herbs to achieve microbial decontamination.

Therefore, the objectives of this study were to examine the effect of electron beam irradiation on the microbial growth and qualities of *Astragalus membranaceus* during storage, and to provide appropriate processing condition for extending the shelf life of the herb.

Materials and Methods

Materials. *A. membranaceus* was purchased from a local market in Daejeon, Korea.

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Electron beam irradiation. Electron beam irradiation was performed using an electron-beam accelerator (Model ELV-4, 1 MeV, Eb-Tech). Samples were individually vacuum-packaged in 120 mm × 60 mm low density polyethylene (LDPE) bags. Samples were exposed to 3 dose levels of 2, 8, and 16 kGy, respectively. Absorption dose was determined using a cellulose triacetate (CTA) dosimeter.

Microbiological analysis. After electron beam irradiation, samples (5 g) were removed from vacuum package using a sterile scalpel. Samples were placed in 45 m*l* 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 Laboratories, Detroit, MI). 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). Both plates were incubated at 37°C for 48 h. For total coliform counts, Chromogenic *E. coli* /Coliform Medium (EC, Oxoid Ltd., Basingstoke, England) was used, and plates were incubated at 37°C for 24 h. During storage, changes of residual total bacteria, yeast and mold, 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 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).

Color measurement. Color of samples was analyzed using

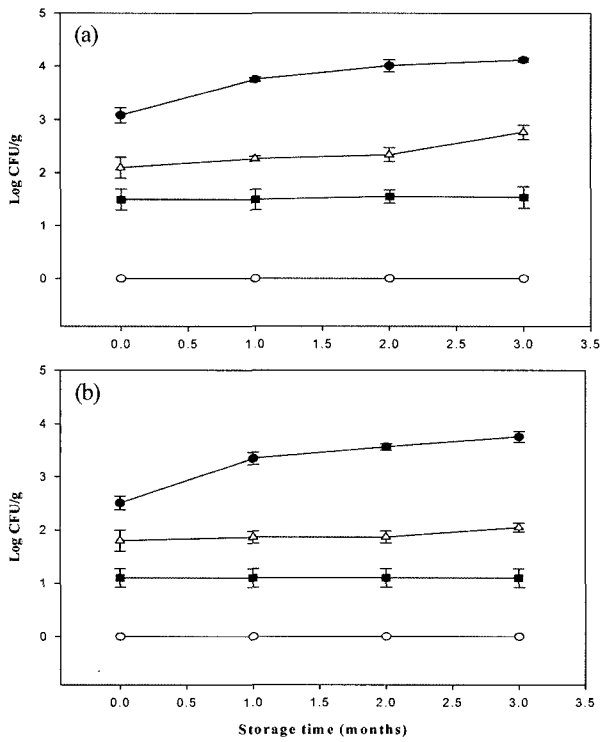

Fig. 1. Effect of electron beam irradiation on microbial growth in *Astragalus membranaceus* at various irradiation doses. Bars represent standard error (n = 3). ●: 0 kGy, △: 2 kGy, ■: 8 kGy, ○: 16 kGy. a: total aerobic bacteria, b: yeast and mold.

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 E 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 of 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 five point scoring method.

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 *A. membranaceus* were 3.08, 2.51, and 1.0 log CFU/g, respectively. Compared to other studies using different medicinal herbs,[2,3] our results are in accordance with initial microbial load in herbs, showing that most medicinal herbs do not have hygienic quality for pharmaceutical or functional food ingredients. Therefore, these results suggest a need of sterilization for the microbial safety of *A. membranaceus*.

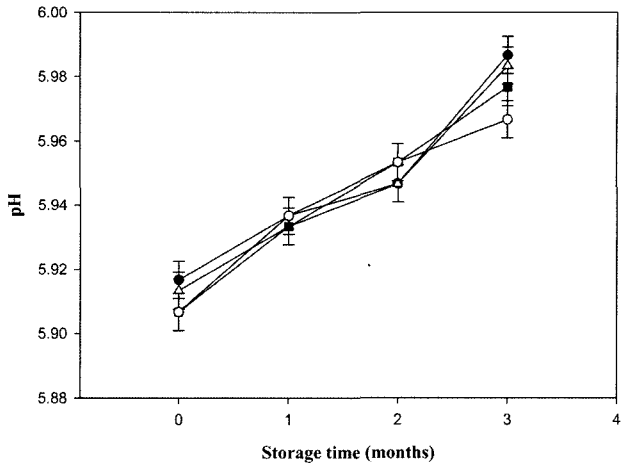

Fig. 2. Changes in pH of irradiated *Astragalus membranaceus* during storage. Bars represent standard error (n = 3). ●: 0 kGy, △: 2 kGy, ■: 8 kGy, ○: 16 kGy.

Electron beam irradiation above 2 kGy completely eliminated coliform bacteria (data not shown), and populations of both total bacteria and yeast and mold were significantly reduced by irradiation (Fig. 1). Increase of radiation dose decreased microbial populations. Total bacteria as well as yeast and mold in samples were eliminated by radiation at 16 kGy. Populations of total bacteria treated with electron beam at 8 kGy were reduced to 1.59 log CFU/g, compared to 3.08 log CFU/g for the non-irradiated sample. In the case of yeast and mold, radiation at 8 kGy decreased from 2.51 log CFU/g to 1.10 log CFU/g. During storage of herbs, populations of total bacteria for the non-irradiated increased to 4.12 log CFU/g after 3 months, while the irradiated herb at 8 kGy reached 1.55 log CFU/g. For populations of yeast and mold, the irradiated herb at 8 kGy had 1.10 log CFU/g, compared to 3.75 log CFU/g.

Only a few studies have been reported on ionizing irradiation on medicinal herbs. Soriani *et al.*[2] reported that gamma irradiation of *Ginkgo biloba* at 11.4 kGy reduced total bacteria to less than 1 log CFU/g, resulting in similar results as ours. There was also a report on the effect of electron beam irradiation of *Calendula officinalis* at 10 kGy, resulting in 2 log cycle reduction in microorganisms.[3]

FAO/IAEA/WHO Expert Committee on food irradiation (JECFI) recommends 10 kGy as a safe upper dose for food irradiation processes, meaning that there is no toxicological evidence at this dose. Our results in this study showed that electron beam irradiation at 8 kGy decreased microorganisms in *A. membranaceus* during storage up to 3 months by 2-3 log cycles, resulting in microbial safety.

Change in pH during storage. Fig. 2 showed that the pH of *A. membranaceus* treated with electron beam irradiation increased during storage. However, there was no significant difference among the treatments during storage. Initial pH values after treatment of *A. membranaceus* with irradiation at 0, 2, 8, and 16 kGy were 5.91, 5.92, 5.91, and 5.91, respectively,

Table 1. Changes in Hunter color values of electron beam irradiated *Astragalus membranaceus*

Color parameter	Storage period (month)	Irradiation dose (kGy) 0	2	8	16
L	0	82.84 ± 1.03[a]	81.03 ± 0.65[a]	82.81 ± 0.45[a]	82.91 ± 1.13[a]
	1	82.99 ± 1.33[a]	80.62 ± 1.34[a]	81.44 ± 0.76[a]	80.82 ± 1.74[a]
	2	81.70 ± 1.34[a]	82.71 ± 1.63[a]	81.55 ± 2.46	80.85 ± 2.10[a]
	3	81.59 ± 2.00[a]	80.34 ± 0.69[a]	82.15 ± 0.82[a]	81.50 ± 0.48[a]
a	0	-1.72 ± 0.80[a]	-1.72 ± 0.64[a]	-1.73 ± 0.16[a]	-1.71 ± 0.14[a]
	1	-1.72 ± 0.27[a]	-1.72 ± 0.41[a]	-1.72 ± 0.17[a]	-1.70 ± 0.17[a]
	2	-1.71 ± 0.55[a]	-1.71 ± 0.76[a]	-1.71 ± 0.09[a]	-1.70 ± 0.09[a]
	3	-1.71 ± 0.76[a]	-1.71 ± 0.73[a]	-1.71 ± 0.70[a]	-1.70 ± 0.70[a]
b	0	23.67 ± 0.35[a]	22.45 ± 1.26[ba]	23.01 ± 0.64[ba]	24.55 ± 0.52[a]
	1	23.32 ± 0.24[a]	24.75 ± 0.60[a]	23.98 ± 0.03[a]	23.63 ± 0.41[a]
	2	22.63 ± 1.57[a]	21.82 ± 0.19[b]	22.61 ± 0.03[ba]	23.83 ± 0.65[a]
	3	21.78 ± 1.50[a]	20.95 ± 0.80[b]	21.64 ± 0.31[b]	22.95 ± 0.21[a]

[a]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 *Astragalus membranaceus* during storage

Organoleptic parameter	Irradiation dose (kGy)	Storage Period (month) 0	1	2	3
Color	0	5.00 ± 0.00[a]	5.00 ± 0.00[a]	5.00 ± 0.00[a]	5.00 ± 0.00[a]
	2	5.00 ± 0.00[a]	5.00 ± 0.00[a]	5.00 ± 0.00[a]	5.00 ± 0.00[a]
	8	4.30 ± 0.58[a]	4.30 ± 0.58[a]	4.30 ± 0.58[a]	4.30 ± 0.58[a]
	16	4.30 ± 0.58[a]	4.30 ± 0.58[a]	4.30 ± 0.58[a]	4.30 ± 0.58[a]
Odor	0	5.00 ± 0.00[a]	5.00 ± 0.00[a]	5.00 ± 0.00[a]	5.00 ± 0.00[a]
	2	5.00 ± 0.00[a]	5.00 ± 0.00[a]	5.00 ± 0.00[a]	5.00 ± 0.00[a]
	8	4.30 ± 0.58[a]	4.30 ± 0.58[a]	4.30 ± 0.58[a]	4.30 ± 0.58[a]
	16	4.30 ± 0.58[a]	4.30 ± 0.58[a]	4.30 ± 0.58[a]	4.30 ± 0.58[a]
Overall	0	5.00 ± 0.00[a]	5.00 ± 0.00[a]	5.00 ± 0.00[a]	5.00 ± 0.00[a]
	2	5.00 ± 0.00[a]	5.00 ± 0.00[a]	5.00 ± 0.00[a]	5.00 ± 0.00[a]
	8	4.70 ± 0.58[a]	4.70 ± 0.58[a]	4.70 ± 0.58[a]	4.70 ± 0.58[a]
	16	4.70 ± 0.58[a]	4.70 ± 0.58[a]	4.70 ± 0.58[a]	4.70 ± 0.58[a]

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

showing that there was no significant change among treatments. These results are unanimous with another report[6] where electron beam irradiation did not affect the pH of mangoes during storage.

Color measurement and sensory evaluation. Color of *A. membranaceus* 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 *A. membranaceus* treated with electron beam at different doses were not significantly different during storage. In general, fumigant treatment and gamma irradiation of high dose for sterilization have been known to decrease the whiteness and increase the yellowness.[7] Our results show that electron beam treatment does not cause color change of *A. membranaceus*, and sensory qualities are observed to be the same among the treatments during storage. These results are similar with our previous report[8] 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, achieving microbial decontamination.

Acknowledgments

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References

1. Rates, S. M. (2001) Plants as source of drugs. *Toxicon* **39**, 603-613.
2. Soriani, R. R., Satomi, L. C. and Pinto, T. J. A. (2005) Effects of ionizing radiation in ginkgo and guarana. *Rad. Phys. Chem.* **73**, 239-242.
3. Minia, R., Nemtanu, M. R., Brasoveanu, M. and Oproiu, C. (2004) Accelerators use for irradiation of fresh medicinal

herbs. Proceedings of European Particle Accelerator Conference, pp. 2368-2370, Lucerne, Switzerland
4. Razem, D. and Katusin-Razem, B. (2002) Dose requirements for microbial decontamination of botanical materials by irradiation. *Rad. Phys. Chem.* **63**, 697-701.
5. Black, J. L. and Jaczynski, J. (2006) Temperature effect on inactivation kinetics of *Escherichia coli* O157:H7 by electron beam in ground beef, chicken breast meat, and trout fillets. *J. Food Sci.* **71**, 221-227.
6. Moreno, M., Castell-Perez, M. E., Gomes, C., Silva, P. F. and Moreira, R. G. (2006) Effects of electron beam irradiation on physical, textural, and microstructural properties of "Tommy Atkins" mangoes. *J. Food Sci.* **71**, 80-86.
7. Lee, J. H., Sung, T. H., Lee, K. T. and Kim, M. R. (2004) Effect of gamma-irradiation on color, pungency, and volatiles of Korean red pepper powder. *J. Food Sci.* **69**, 585-592.
8. Ko, J. K., Ma, Y. H. and Song, K. B. (2005) Effect of electron beam irradiation on microbial qualities of whole black pepper powder and commercial *Sunsik*. *Korean J. Food Sci. Technol.* **37**, 308-312.