

# Quality Evaluation of Ground Garlic and Onions Treated with Chemical Fumigants and Ionizing Radiation

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## 마늘 및 양파 분말의 품질에 대한 화학 훈증제와 감마선 처리의 비교 연구

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### Abstract

Comparative effects of ethylene oxide and gamma radiation treatment of the microbiological and physicochemical qualities of ground garlic and onions were investigated. The standard ethylene oxide cycle employed was substantially less effective in reducing microbial counts than were 7 and 10 kGy of gamma radiation, and was roughly comparable to 5 kGy. Effects of gamma radiation on pungency, nutrient and color were relativey small in comparison with ethylene oxide which adversely affected physicochemical properties. Sensory evaluation indicated that no significant difference was observed between the nontreated control group and 10 kGy irradiated samples.

### Introduction

Spice is essential to food processing and its quality has a great influence on that of processed food. Most spices, imported or domestic, are highly contaminated by various microorganisms such as thermophiles, aerobic spores, molds, pathogenic bacteria and coliform group.<sup>(1)</sup> It has been reported that the numerous contamination in spices, occurring mainly during harvesting, handling, transportation and storage, might cause serious problems in the food industry viewed from public health and quality control aspects of the products.<sup>(2-4)</sup> Even though there are several methods used for sterilizing spices, such as heat treatment, ultra violet and microwave energy, and chemical fumigants, they have many problems in terms of ineffectiveness and complexity of treatment, adverse effects on the quality, chemical residues, and treatment cost and capacity.<sup>(5-8)</sup>

Currently, ethylene oxide (ETO) fumigation is domestically used to reduce the microbial load of spices. However, it has been indicated that this treatment can be costly and time consuming, and furthermore, undesirable effects on the flavor and color qualities of spices have been known in some cases.<sup>(5,9)</sup> Moreover,

since the use of chemical fumigants for food and foodstuffs has already been prohibited in some countries,<sup>(10,11)</sup> there is an urgent need to develop an effective alternative method.

Garlic and onion powders are widely used in many processed foods or seasoning blends. Onions as well as garlic are known to have antimicrobial activity and have been used as natural antibiotics.<sup>(12)</sup> However, dehydrated ground garlic and onions usually do not undergo any sterilization step in the course of their manufacturing process and thus carry with them a portion of the microbial flora present in the raw material. Even though the dehydration process reduces some microbial populations, the remaining microbial flora may cause spoilage when they are used as ingredients in processed food.

Since food irradiation was recognized as a physical treatment comparable to heating or freezing of food, the Codex Alimentarius Commission (CAC) of the United Nations (FAO/WHO), representing some 120 governments, set specific standards for food irradiation and ruled in 1983 that any food commodities processed with up to a 10 kGy absorbed dose retained their wholesomeness.<sup>(13,14)</sup> Recently, with the awareness of the distinct advantages of food irradiation over other methods, thirty-two countries have

collectively approved 227 food items in 73 food groups for human consumption, especially for space food and aseptic food suitable for hospital patients, on either an unconditional or a restricted basis.<sup>(15)</sup>

The decontamination of spices is one of the most promising applications in the field of food irradiation. Therefore, the present study was a part of recent extensive work undertaken in order to commercialize food irradiation technology in Korea. The purpose of the study was to ascertain the efficacy of gamma irradiation as a means of sterilizing ground garlic and onions as compared with that of the conventional Ethylene Oxide (ETO) method.

## Materials and Methods

### Materials

Garlic and onion powders used were imported products and obtained from a local company near Seoul.

### Ethylene oxide fumigation

The ETO treatment was carried out on spices in small packaging bags, laminated 20 $\mu$ m nylon with 60 $\mu$ m polyethylene, according to commercial practices. The ETO sterilizer resembled an autoclave chamber and a gas, consisting of a mixture of 30% ETO and 70% carbon dioxide by weight, was used. The treatment conditions were as follows: operating temperature, 50°C; humidity, 40%; gas pressure, 0.8 kg/cm<sup>2</sup>G; gas density, 1.77 kg/m<sup>3</sup>; treatment time, 8 hours.

### Irradiation treatment

The samples packaged were irradiated at ambient temperatures by a 10 kilo curie Co-60 gamma irradiator (U.K., 30 Gy/hr) with doses of 5, 7 and 10 kGy.

All samples treated with ETO and with gamma radiation were stored together with the nontreated control sample at room temperatures (12–18°C) for 3 months.

### Microbiological examinations

Enumeration of total aerobic bacteria was performed on the spices according to the standard APHA method<sup>(16)</sup> except that the incubation temperature was 30°C. Aerobic spores and acid tolerant bacteria were counted using TGY agar after treatment at 80°C for 10 min., and tomato juice agar (Difco. Lab.), respectively.<sup>(17)</sup> Fungi were counted

by MYG—chloramphenicol agar containing malt extract, 10 g; yeast extract, 4 g; glucose, 4 g; agar, 20 g; and chloramphenicol, 20 mg per liter (pH 6.0) with incubation at 30°C for 3-5 days.<sup>(12)</sup>

### Analysis of nutrients

The AOAC standard methods<sup>(18)</sup> were used in order to determine moisture, protein, fat, ash and ascorbic acid, while carbohydrates were calculated by difference.

### Determination of pyruvic acid

Total pyruvic acid content was determined according to the method of Schwimmer and Weston.<sup>(19)</sup>

### Determination of color

The color change in ground garlic and onions was determined using a Hunter Color Difference Meter (Model D25-9) for the three parameters of color, i.e., L-lightness, a-redness and b-yellowness.

### Sensory evaluations

Immediately after the sterilizing treatment three samples — the nontreated control, 10 kGy irradiation and ETO fumigation group — were subjected to sensory evaluation, which put emphasis on the overall acceptability of the product in terms of the flavor and appearance of the spices. The sensory test was performed by the ranking difference analysis obtained from the Methods in Sensory Evaluation of Food<sup>(20)</sup> and the panel consisted of eight individuals experienced in sensory evaluation. All figures reported here represent the mean of triplicate experiments.

## Results and Discussion

### Inactivation of microorganisms

The comparative effects of ethylene oxide fumigation and gamma irradiation on the inactivation of microbial flora contaminating garlic and onion powders were given in Table 1 and 2.

The garlic powder showed some higher microbial populations than onion powder and the distribution of microbial flora, including aerobic spores, acid tolerant bacteria and fungi was found to be similar in both spices. A dose of 7-10 kGy gamma irradiation could reduce the load of microorganisms to below 10<sup>3</sup> or less per gram:

however, ETO fumigation proved to be insufficient to reduce the microbial flora to a level of  $10^3$  per gram, which has generally been regarded as a hygienic standard for spices.<sup>(2)</sup>

The gamma radiation treatment of spices indicated that different doses would be required for the total destruction of microorganisms and similar results were reported for some selected spices.<sup>(1,4,5)</sup> After three months of storage, no apparent growth of microorganisms occurred in all stored samples.

### Effect on nutrients

While garlic and onion powders are used primarily for their flavor rather than their nutritional value, proximate components were analyzed to determine the comparative effects of ETO fumigation and irradiation at doses for radication.

As shown in Table 3, the amount of all components, including carbohydrates, was little affected by the steriliz-

ing treatments, showing a similar tendency in both spices. However, ETO fumigation seemed to have a larger effect on the ascorbic acid content than irradiation treatment in both spices. Elias and Cohen<sup>(21)</sup> reported that although ionizing radiation at 10–150 kGy might cause a loss in ascorbic acid content, the extent to which it changed rarely exceeded 20-30%, and also in some cases it remained unchanged or increased on irradiation treatment. In this experiment, the result of the irradiation treatment on ascorbic acid was in reasonable agreement with that of Galetto et al.<sup>(22)</sup>

### Effect on pyruvic acid content

The garlic and onion powders were analyzed for pyruvic acid content immediately after sterilizing treatments and after three months of storage. Increasing doses of gamma irradiation resulted in an almost linear reduction of the content of pyruvic acid, but there was no significant reduction within the applied doses (Table 4); while ETO fumiga-

**Table 1. Comparative effect of gamma irradiation and ethylene oxide (ETO) fumigation on the microbial flora of garlic powder**

Treatments	Number of microorganisms per gram			
	Total aerobic bacteria	Aerobic spores	Acid tolerant bacteria	Fungi
Control	$2.08 \times 10^6$	$1.28 \times 10^5$	$6.00 \times 10^5$	$1.00 \times 10^3$
5 kGy <sup>a</sup>	$1.55 \times 10^4$	$7.40 \times 10^3$	$3.80 \times 10^3$	$1.00 \times 10^2$
7 KGy	$5.00 \times 10^3$	$1.80 \times 10^3$	$2.98 \times 10^2$	0.0
10 kGy	$5.00 \times 10^2$	$2.00 \times 10^2$	0.0	0.0
ETO <sup>b</sup>	$1.23 \times 10^4$	$8.10 \times 10^3$	$2.95 \times 10^2$	0.0

<sup>a</sup> The unit used to measure an absorbed dose of radiation and 1 kGy is equivalent to 100 krad

<sup>b</sup> Treatment conditions are given in the text

**Table 2. Comparative effect of gamma irradiation and ethylene oxide (ETO) fumigation on the microbial flora of onion powder**

Treatments	Number of microorganisms per gram			
	Total aerobic bacteria	Aerobic spores	Acid tolerant bacteria	Fungi
Control	$7.20 \times 10^5$	$4.46 \times 10^4$	$4.25 \times 10^5$	$1.20 \times 10^2$
5 kGy <sup>a</sup>	$5.40 \times 10^3$	$4.40 \times 10^3$	$3.80 \times 10^3$	0.0
7 KGy	$2.50 \times 10^3$	$2.10 \times 10^2$	$1.40 \times 10^2$	0.0
10 kGy	0.0	0.0	0.0	0.0
ETO <sup>b</sup>	$5.46 \times 10^3$	$3.30 \times 10^3$	$2.20 \times 10^3$	0.0

<sup>a</sup> The unit used to measure an absorbed dose of radiation and 1 kGy is equivalent to 100 krad

<sup>b</sup> Treatment conditions are given in the text

the potential use of pyruvic acid determination as an indicator for evaluation of dehydrated product quality.<sup>(24,25)</sup> The results on the measurement of pyruvic acid was shown to be well correlated with those of sensory evaluations, which are to be presented later in this paper.

### Color and sensory properties

The results of the Hunter color measurements for the ground garlic and onions are given in Table 5. Gamma radiation treatment somewhat increased only yellowness of both spices in comparison to ETO fumigation which brought about the changes not only in yellowness but also in redness and lightness. Visually, ETO treated samples were dull and darker in color, while no noticeable difference in color was observed between the nontreated control and

the gamma irradiated samples. The color differences remained during storage. Similar results were reported for ground onions, paprika and ginger.<sup>(1,5,22)</sup>

tion brought about a significant reduction ( $p < 0.01$ ) in pyruvic acid content of both spices. The difference in the amount of pyruvic acid among the treatment groups gradually decreased with the storage period.

Since good correlations between development of pyruvic acid and odor intensity in fresh *Allium* species were reported,<sup>(19,23)</sup> there have been several reports on

Immediately after the sterilizing treatments, sensory evaluations were made on the nontreated control, 10 kGy irradiated and ETO fumigated samples in order to elucidate the comparative effects of ETO fumigation and gamma irradiation on the overall acceptability of the spices. The

**Table 3. Effect of gamma irradiation and ethylene oxide (ETO) fumigation on the nutrients of garlic and onion powders\***

Components	Treatments									
	Control		5 kGy <sup>b</sup>		7 kGy		10 kGy		ETO <sup>c</sup>	
	Garlic	Onion	Garlic	Onion	Garlic	Onion	Garlic	Onion	Garlic	Onion
Moisture (%)	9.9	10.0	9.8	10.1	9.9	10.2	10.0	10.2	10.2	10.4
Protein (%)	14.2	8.6	14.1	8.7	14.2	8.7	14.0	8.6	14.1	8.6
Fat (%)	1.2	1.1	1.2	1.2	1.3	1.2	1.3	1.1	1.3	1.3
Ash (%)	3.2	4.1	3.2	4.0	3.2	4.0	3.1	4.1	3.2	4.1
Carbohydrates (%)	71.5	76.2	71.7	76.0	71.4	75.9	71.6	76.0	71.2	75.6
Ascorbic acid (mg/100g)	16.8	18.4	16.4	18.4	16.0	18.1	15.4	17.6	14.6	15.7

\* Each value is the mean of triplicate experiments

<sup>b</sup> The unit used to measure an absorbed dose of radiation and 1 kGy is equivalent to 100 krad

<sup>c</sup> Treatment conditions are given in the text

**Table 4. Effect of gamma irradiation and ethylene oxide (ETO) fumigation on the total pyruvic acid content of garlic and onion powders\***

Spices	Storage period (month)	Treatments				
		Control	5 kGy <sup>b</sup>	7 kGy	10 kGy	ETO <sup>c</sup>
Garlic powder	0	47.14	46.03	45.47	44.10	31.61 <sup>d</sup>
	3	41.48	41.18	41.14	39.16	28.86
Onion powder	0	15.65	14.84	14.61	14.10	13.40 <sup>d</sup>
	3	13.40	13.16	13.20	12.82	11.68

\* Pyruvate content is expressed as  $\mu$ moles per gram of samples on the basis of dry weight and each value is the mean of triplicate experiments

<sup>b</sup> The unit used to measure an absorbed dose of radiation and 1 kGy is equivalent to 100 krad

<sup>c</sup> Treatment conditions are given in the text

<sup>d</sup> Significantly reduced as compared to the control sample ( $p < 0.01$ )

data for three samples were analyzed statistically by analysis of variance and a Duncan's multiple range test, as summarized in Table 6. The results showed that the sample fumigated with ETO was significantly different in the flavor evaluations from the 10 kGy irradiated sample as well as the nontreated control samples, in garlic ( $p < 0.05$ ) and onion ( $p < 0.01$ ) powders; whereas no significant difference was observed between the nontreated and the gamma irradiated spices.

From the results of this work, it can be concluded that gamma radiation treatment is not only more effective in reducing the microbial population of spices but also less detrimental to their physicochemical and sensory quality than ethylene oxide fumigation. Therefore, it seems that a suitable application of irradiation dose, depending on the kinds of spices, successfully contributes to the improvement of hygienic status and storage stability of

spices.

In Korea, the approval of the wholesomeness of irradiated food was declared by a Presidential decree in July 1985. And also the procedures for permission of individual items and the construction of a commercial multipurpose food irradiation facility are in progress.

## 요 약

현행의 ethylene oxide 훈증 처리와 감마선 조사가 마늘 및 양파 분말에 오염된 미생물의 살균과 이에 따른 제품의 이화학적 품질에 미치는 영향을 검토한 결과, 시료에 오염된 미생물 즉, 일반 세균, 내열성 포자균, 산저항성 세균 및 곰팡이류는 훈증제 처리로서 살균 효과가 불충분하였으나 7-10 kGy 조사구에서는 살균 및 10<sup>3.8</sup> 이하의 감균이 가능하였다. 훈증제 처리와 살균 선량의 감마선 조사는 다같이 시료의 품질에 관련된 신미 성분,

**Table 5. Comparative effect of gamma irradiation and ethylene oxide (ETO) fumigation on the color of garlic and onion powders\***

Treatment	L <sup>b</sup>		a <sup>b</sup>		b <sup>b</sup>	
	Garlic	Onion	Garlic	Onion	Garlic	Onion
Control	77.78	70.39	1.36	-0.11	17.88	24.86
10 kGy <sup>c</sup>	77.57	70.99	1.42	-0.09	18.83	25.58
ETO <sup>d</sup>	73.45	63.71	1.73	1.45	20.75	26.18

\* Each value is the mean of triplicate experiment

<sup>b</sup> L: Degree of lightness (white  $\times$  100  $\leftrightarrow$  0 black)

a: Degree of redness (red + 100  $\leftrightarrow$  0  $\leftrightarrow$  -80 green)

b: Degree of yellowness (yellowness + 70  $\leftrightarrow$  0  $\leftrightarrow$  -80 blue)

<sup>c</sup> The unit used to measure and absorbed dose of radiation and 1 kGy is equivalent to 100 krad

<sup>d</sup> Treatment conditions are given in the text

**Table 6. F value calculated by the analysis of variance and Duncan's multiple range test of ranking difference test for the sensory quality of garlic and onion powders treated with gamma radiation and ethylene oxide (ETO)\***

Spices	F value <sup>b</sup>	Sample mean <sup>c</sup>		
		Control	10 kGy	ETO
Garlic powder	4.41	0.32	0.21	-0.53
Onion powder	31.00	0.43	0.43	-0.85

\* Sensory evaluation was conducted by a panel of 8 members immediately after the sterilizing treatment, putting emphasis on the overall acceptability of the product in terms of the flavor and appearance of the spices

<sup>b</sup> F value must exceed 3.47 to be significant at the 5% level and it must exceed 5.78 to be significant at the 1% level

<sup>c</sup> A common underline in the row means that both the nontreated control and 10 kGy irradiated samples are significantly different from ETO treated samples at the 5% level in garlic powder and 1% level in onion powder, respectively from the Duncan's multiple range test

풍미, 색도 등에 어느 정도 영향을 미쳤으나 훈증 처리 시료는 보다 현저하였다. 살균 처리 직후 제품의 전반적인 풍미 및 선택에 대한 관능 시험에서는 감마선 조사 시료와 대조 시료간에는 유의적인 차이가 없었으나 훈증처리된 시료는 대조 및 감마선 조사 시료와 마늘 및 양파 분말에서 각각 5%와 1% 수준에서 유의적인 차이를 나타내었다.

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