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Sanitary Sterilization of Dried Fishes and Mixed Condiments

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주요건조 수산물 및 혼합조미료의 위생적 살균

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요 약

건조 수산가공품 및 혼합조미료 각 5종의 위생적 살균 및 저장방법의 개발을 목적으로 현행살균방법으로 살균효과의 불충분, 제품의 품질저하, 약제성분의 잔유 등 많은 문제점을 내포한 ethylene oxide에 의한 훈증처리와 방사선 조사와의 미생물 살균효과, 이화학적 특성 및 관능적 품질에 미치는 영향을 검토한 결과는 다음과 같다. 시료의 미생물 오염은 전세균이 10^3~10^7 CFU/g으로 그중 90%이상이 내열성 세균이었으며, 곰팡이류는 10^2~10^3 CFU/g, 대장균도 시료 5종에서 10^2~10^6 CFU/g이나 오염되었다. 살균효과 실험에서 대장균군, 곰팡이류는 5~10 kGy 방사선 조사로서 완전 사멸되었으며, 전세균도 오염도가 매우 높았던 혼합조미료 몇종을 제외하고는 제거되었다.

반면, ethylene oxide 훈증처리는 전 미생물의 살균이 불충분 하였다. 이 화학적 특성 즉, TBA가 TMA-N 함량, 아미노산, 무기질, 색도 등은 적정 선량의 방사선 조사로서는 무처리구 시료와 거의 차이가 없었으나, ethylene oxide 훈증처리구는 심한 품질의 변화를 나타내었다. 또한 관능검사에 의한 전반적 기호성에 있어서도 방사선조사구가 무처리구 및 ethylene oxide 처리구보다 유의적으로 우수함을 나타냈다.

Introduction

Even thought there are several methods used for sterilizing agricultural and fishery products, such as heat treatment[1,2], ultra violet and microwave energy[3,4] and chemical fumigants[2,4], they present many problems such as adverse effets on quality, ineffectiveness of threatment, chemical residuces and environmental pollution. Therefore, gamma irradiation is recommended by the health authorities concerned as an alternative to conventional method[5].

The changes in eating habits and the rise in the standard of living in Korea have accelerated the demand for convenience food production, and for

this reason it is essential that raw materials of good quality and reasonable price be available all the year round.

Since the commerical utilization of food irradiation in Korea has been required, contributing to the indirect production of foodstuffs by reducing storage loss, stabilization of food prices, sanitary distribution of processed food, and on increase in the export of agricultural and marine products with an increament in value added, a semi-commerical scale study has been conducted by Korea Advanced Energy Research Institute (KAERI) since 1980. As a result of the intensive research, Goverment authorities approved food irradiation as a new method of food preservation in 1985. Moreover, the construction of a commerical food irradiator, 500 KCi (shielding capacity; 30,000,000 Ci) was completed in 1987 by a small and medium industry, which has been technically supported by KAERI for over five years.

The actual export of fishery products in Korea is fifth in the world and 81% of total animal protein demand was supplied by the fish and fishery products in the interior but the traditional storage method of dried fishes has problems in the loss by insect and microorganisms, sanitary status and chemical residues. Mixed condiments, as the minor ingredients in manufacturing of convenince food, are various in species and the microbiological quality of raw ingredients of a condiment has a great influence on that of the end products.

Thus, there is an urgent need to develop an alternative means over the conventional ethylene oxide fumigation, because most chemical fumigants have recently been banned in several western countries owing to their suspected safety and ineffectiveness.

The decontamination of dried food products is one of the most promising applications in the field of food products is one of the most promising applications in the field of food irradiation. Therefore, the project was intended to ascertain the efficacy of gamma irradiation as a means of sterilizing for selected mixed condiments and marine products as compared with that of chemical fumigation.

Under the ambient temperature storage conditions, the investigation the sterilization effects of irradiation and ethylene oxide fumigation on contaminated microorganisms and physicochemical qualities of the treated sample were evaluated by determining pH, rancidity (TBA number), TMA-N, minerals, amino acids, color changes and sensory quality.

Material and Methods

Materials

Major dried fishes (shrimp, shucked shellfish, shucked mussel, anchovy, squid) and mixed condiments (beef extract, chung-kugzang, soybean paste, anchovy extract, soup of instant noodle) were obtained from major food processing compaines in Korea.

Gamma Irradiation

In irradiation, each samples were aerobically packed into pouch laminated with 20 μm nylone/60 μm ployethylene. The irradiation was carried out at room temperature with dose rate of 40 Gy/hr (10 kci Co-60 gamma irradiator).The does levels applied were 0,3,5,7 and 10 kGy.

Ethlene oxide fumigation

Fumigation was carried out with ethylene oxide (E.O) by domestic special gas treatment company (E. O : CO=3 : 7 wt%, gas pressure: 0.8 kg/cm^2 G, gas density; 1.77 kg/cm, temp: 55℃, RH: 40~50%, treatment time: 8 hours). All samples treated with E.O and with gamma irradiation were stored together with the nontreated control sample at room temperature for 3 months.

Enumeration of microbial load

Total mesophilic aerobic bacteria was counted by

the surface plate agar method with TGY agar (Difco, Lab.). Mesophilic aerobic spores and acid tolerant bacteria were counted using TGY agar after treatment at 80℃ for 10 min., and tomato juice agar (Difco, Lab.), respectively. 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). Osmophilic molds were counted by 15% NaCl-malt agar containing malt extract 50 g, NaCl 150 g, and agar 20 g per liter (pH 6.0). Coliforms was determined by desoxycholate agar (Difco. Lab.). Total aerobic bacteria, fungi and osmophilic molds were counted after 2 to 7 days incubation at 30℃. Coliforms was counted after 1 to 2 days incubation at 37℃[6~9].

Analysis of physicochemical properties

pH was determined by AOAC standard method[10]. Amino acid composition was analysed after acid hydrolysis, followed by a chromatographic seperation of the amino acids in the hydrolysates by means of automatic amino acid analyser. Mineral content in samples was determined by using an atomic absorption spectrophotometer (Instrumental Lab. Inc. Model 457) according to the wet combusiton method[17]. TBA value in samples as an index of lipid rancidity was determined by Turner's method[11].

TMA-nitrogen content of dried fish was determined by Murray and Gibson's method[12]. The color change in samples was determined using a color and color difference meter (Nippon Denshoku Kogyo Co. Model 1001) for the three parameters of color (L: lightness, a: redness, b: yellowness).

Sensory evaluation

After three months of storage at room temperature, four samples such as the nontreated control, 5 and 10 kGy irradiation, and E.O fumigation group were tested by 8 panel members according to the ranking difference analysis of shiffing method[13].

Results and Discussion

Distribution of microorganisms in dried fishes and mixed condiments

Damage to dried foods caused by insects or microorganisms in considerable in Korea because summer

Table 1. Distribution of microorganisms in dried fishes and mixed condiments (Colony forming units/g)

Products	Mesophilic aerobic total bacteria	Mesophilic aerobic spores	Acid tolerant bacteria	Molds	Coliforms
Shrimp powder	4.0×10^7	2.0×10^6	4.6×10^6	7.1×10^2	6.4×10^2
Shucked shellfish powder	2.1×10^5	1.5×10^4	1.5×10^3	2.0×10^2	6.9×10^3
Shucked mussel powder	3.7×10^6	4.0×10^2	5.1×10^5	5.0×10^2	1.2×10^5
Anchovy powder	1.7×10^3	2.1×10^2	2.0×10^2	–	–
Squid powder	2.2×10^4	6.1×10^2	1.3×10^4	–	5.8×10^4
Beefextracts condiment	1.9×10^4	7.9×10^3	1.2×10^4	–	–
Chung–Kug–Zang condiment	3.6×10^7	1.5×10^7	1.3×10^7	1.2×10^3	3.6×10^6
Soybean paste's condiment	8.4×10^6	7.9×10^6	6.6×10^6	5.9×10^2	–
Anchovy extract's condiment	2.7×10^5	1.1×10^5	7.9×10^3	–	–
Ramen's Condiments (Soup)	3.9×10^6	3.6×10^6	1.0×10^6	4.5×10^3	–

humidity and temperature are high enough to allow fungal and bacteria growth.

The viable cell counts for samples of different origins show deviation in several contamination, as shown in Table 1. Population of mesophilic total bacteria, aerobic spores and acid tolerant bacterial of samples were 10^3 to 10^7 CFU/g, 10^2 to 10^6 CFU/g, and 10^3 to 10^7 CFU/g, respectively. Mesophilic total bacteria counts were mainly composed of thermophiles and acid tolerant bacteria by over 90%. Molds were determined in 8 samples to be 10^2 to 10^3 CFU/g. Especially, Coliforms was also detected in 5 samples and the range was from 10^2 to 10^6 CFU/g, indicating that most of the products were prepared under unsanitary conditions. In this respect, it seems to be necessary to prevent damage to dried foods caused by the growth of microorganisms and insects, and to eliminate pathogens.

Inactivation of microorganisms

The comparative effects of E.O fumigation and gamma irradiation on the inactiviation of microbial flora contaminating samples were given in Fig. 1 and Table 2.

In the dried fishes, total aerobic and acid tolerant bacteria were reduced by 2 to 3 log orders by gamma irradiation at 3 to 5 kGy. The sterilizing doses for coliforms, fungi and total bacterial count were shown to be 5 kGy, 5 to 7 kGy, and 7 to 10 kGy, respectively. D_{10} values of total bacterial count in dried fishes ranged from 0.80 to 3.99 kGy. In the meantime, E.O treatment proved insufficient to

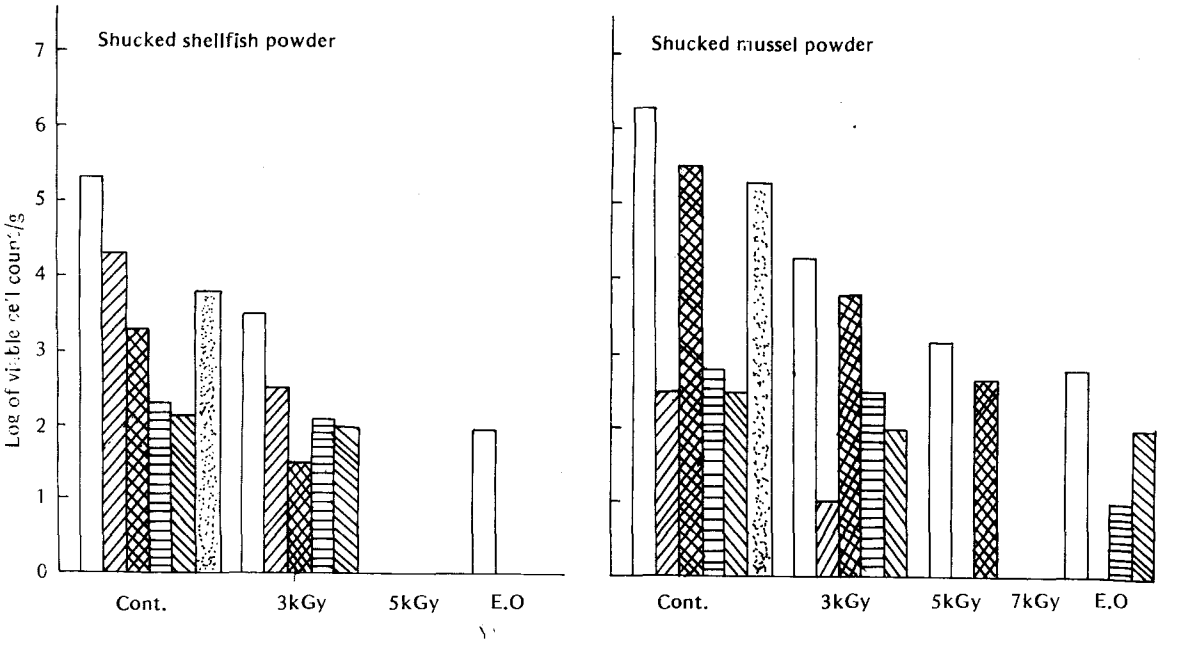

Fig. 1. The comparative effect of ethylene oxide (E.O) and gamma irradiation on the microflora of shucked shellfish and shucked mussel powder.

Table 2. Comparative effects of ethylene oxide fumigation and gamma irradiation on microorganisms of dried fishes and mixed condiments. (Colony forming units/g)

Products	Treatments								
	Control			Ethylene oxide*			Gamma irradiation**		
	Mesophilic total count	Mesophilic aerobic spores	Molds	Mesophilic total count	Mesophilic aerobic spores	Molds	Mesophilic total count	Mesophilic aerobic spores	Molds
Shrimp powder	4.0×10^7	2.0×10^6	$71. \times 10^2$	2.0×10^4	8.0×10^3	3.0×10^2	0	0	0
Shucked shellfish powder	2.1×10^5	1.5×10^4	2.0×10^2	1.6×10^2	0	0	0	0	0
Shucked mussel powder	3.7×10^6	4.0×10^2	5.0×10^2	9.0×10^2	0	1.0×10^2	0	0	0
Anchovy powder	1.7×10^3	2.1×10	0	0	0	0	0	0	0
Squid powder	2.2×10^4	6.1×10^2	0	0	0	0	0	0	0
Beef extract's condiment	1.9×10^4	7.9×10^3	–	0	0	0	0	0	0
Chung –Kug–zang condiment	3.6×10^7	1.5×10^7	1.2×10^3	3.1×10^4	1.8×10^4	1.1×10^2	5.9×10^3	1.2×10^3	0
Soybean paste's condiment	8.4×10^6	7.9×10^6	5.9×10^2	2.3×10^4	4.6×10^3	2.6×10^1	1.0×10^3	2.1×10^2	0
Anchovy extract's condiment	2.7×10^5	1.1×10^5	0	1.7×10^2	0	0	1.1×10^2	0	0
Ramen's condiment (soup)	3.9×10^6	3.6×10^6	4.5×10^3	8.9×10^2	2.4×10^2	1.3×10^2	0	0	0

* 30% ethylene oxide gas, 55°C, 0.8kg/cm² G, 8hrs ** 10kGy irradiation

reduced the microbial load of highly contaminated samples below the 10^3 per gram of the international hygineic standard, especially in total aerobic bacteria, thermophiles and fungi.

In the mixed condiments, 7 to 10 kGy gamma irradiation could eliminate coliforms and molds, and also bring about the reduction of mesophilic total bacteria load to below around 10^3 CFU/g. D_{10} values of the total bacterial count of the samples ranged from 1.91 to 3.33 kGy. However, more than 10 kGy was required for destroying aerobic spores contaminated in the condiments such as Chung-Kug-Zang, soybean paste and anchovy extracts, as proved in the higher D_{10} values ranging 3.57~5.16 kGy.

After three months of storage at room temperature, no apparent growth of microorganisms occured in 7 to 10 kGy irradiated samples. These results are similar to the reports of Ito et al.[13], Farkas et al[10], Ahmed[15] and Kumta[16].

Effects on physicochemical properties and sensory evaluation

The comparative effcts of E.O fumigation and gamma irradiation on the physicochemical quality of the sample were given in Table 3~6.

In the dried fishes, an optimum dose of irradiation had little detrimental effect on the chemical components of the sample, but E.O. treatment brought about a significant reduction especially in amino acid. The values of thiobarbituric acid (TBA), pH and trimethyleamin (TMA), as quality parameters, were more stable during the storage period in the irradiated groups than the control and E.O groups.

Compared with an optimum dose of irradiation, E. O treatment caused changes in color, leading to deterioration of overall appearance of the samples. The mineral content of dried fish are shown in Table 6. The mineral content of dried fish was not affected by sterilization treatmet. This result is similar to report by cho et al[16]. As shown in Table 7, sensory evaluation after three months of storage at room temperatures indicated that the irradiated samples with does of 5 to 10 kGy were more acceptable in the overall flavor and appearance of each product than the nontreated control group as well as the E.O fumigated samples.

In the mixed condiments, both treatments (6.0 and gomma irradiation) affected more or less on rancidity, color and amino acid content, but less than 10 kGy irradiation was shown to be safer than E.O fumigation.

Table 3. Comparative effects of ethylene oxide (E. O) fumigation and irradiation on the chemical components of dried fish and mixed condiments[a]

Treatment	Storage Period (month)	TBA (MA mg/kg)		TMA-N (mg/100g)		pH	
		A[b]	B[c]	A	B	A	B
Control	0	9.25	13.21	8.01	—	7.24	5.36
	3	16.10	21.42	10.51	—	7.42	5.62
5kGy	0	9.64	14.34	7.93	—	7.24	5.32
	3	12.35	18.35	9.98	—	7.40	5.48
10kGy	0	10.12	15.70	8.02	—	7.24	5.28
	3	12.86	19.28	10.00	—	7.39	5.39
E. O	0	10.63	15.92	8.03	—	7.25	5.38
	3	13.66	23.63	10.48	—	7.46	5.51

[a] The value is the mean of triplicate experiments and is expressed on the basis of dry weight, [b]Shrimp powder, [c]Beef extract's condiment.

Table 4. Comparative effects of ethylene oxide (E. O) fumigation and gamma irradiation on the color of dried fish and mixed condiment[a]

Products	Treatments	Color parameters			
		Lightness (L)	Redness (a)	Yellowness (b)	Δ E[b]
Shrimp powder	Control	60.5 (57.1)[c]	13.4 (10.0)	21.5 (22.8)	0.0 (0.0)
	5 kGy	62.0 (57.1)	11.6 (10.4)	22.8 (23.3)	2.7 (0.6)
	10 kGy	61.7 (57.1)	12.1 (10.0)	22.8 (23.5)	2.2 (0.7)
	E. O	63.6 (58.3)	11.2 (11.3)	25.5 (26.0)	5.5 (3.6)
Beef extract's condiment	Control	37.4	−7.3	−12.8	0.0
	5 kGy	41.4	−7.2	−13.0	1.7
	10 kGy	43.1	−6.1	−13.4	5.7
	E. O	27.2	11.0	17.1	11.7

[a] The value is the mean of triplicate experiments and is expressed on the basis of dry weight.
[b] Color difference.
[c] Number in parenthesis designates the value of three months of storage.

Table 5. Comparative effects of ethylene oxide (E. O) fumigation and gamma irradiation on the amino acid content of dried fishes[a]

Amino acid	Treatments							
	Control		5kGy		10kGy		E. O	
	A[b]	B[c]	A	B	A	B	A	B
Aspartic acid	4.28	5.95	4.15	5.48	5.35	4.00	4.73	3.93
Threonine	1.34	1.82	1.31	2.01	1.95	1.24	1.55	1.23
Serine	1.87	2.53	1.80	2.67	2.30	1.70	1.92	1.67
Glutamic acid	5.62	7.94	5.49	7.66	7.26	5.22	6.10	5.05
Glycine	4.33	4.22	4.14	4.24	3.71	4.02	3.47	3.83
Alanine	2.82	4.56	2.75	4.28	4.22	2.65	3.49	2.53
Cysteine	—	0.51	—	—	—	—	—	—
Valine	1.30	1.05	1.27	1.03	1.03	1.21	1.12	1.15
Mothionine	1.07	1.26	1.04	1.21	1.19	1.02	1.17	0.92
Isoleucine	2.21	1.12	2.17	1.14	1.09	2.11	0.88	2.08
Leucine	2.57	3.09	2.85	2.94	2.97	2.69	2.67	2.58
Tyrosine	1.25	1.07	1.14	1.24	1.16	1.17	1.07	1.15
Phenylalanine	1.97	2.20	1.92	2.02	2.13	1.79	1.88	1.70
Lysine	2.55	3.18	2.47	3.14	3.12	2.38	2.60	2.29
NH	0.42	0.90	0.41	0.86	0.69	0.39	0.65	0.37
Histidine	0.57	0.44	0.56	0.51	0.44	0.53	0.45	0.38
Arginine	3.25	3.63	3.09	3.06	3.15	2.97	2.95	2.83
Proline	4.24	2.57	3.99	2.26	2.26	3.99	2.47	4.30
Total	41.66	48.04	40.55	45.75	44.02	39.08	39.17	37.99

[a] Total amino acid content is expressed as the percentage on the basis of dry weight immediately after treatments.
[b] Shrimp powder, [c] Shucked shellfish powder

Table 6. Comparative effects of ethylene oxide (E. O) fumigation gamma irradiation on the mineral content of anchovy powder[a]

Treatments	Mineral content (mg/100g, dry wt.)						
	Na	K	Ca	Mg	Cu	Fe	Zn
Control	2063	714.3	677.2	222.2	0.58	359.8	16.7
10 kGy	2050	714.0	678.6	219.8	0.60	359.6	16.1
E. O	2038	714.1	679.4	220.1	0.58	359.6	15.8

[a] Minerals were analyzer with A. A. immediately after treatments and each value is the mean of triplicate experiments

Table 7. Results of sensory evaluation for the overall acceptability of dried fishes treated with ethylene oxide (E. O) and gamma irradiation by ranking difference analysis[a]

Products	Treatments			
	Control	5kGy	10kGy	E. O
Shucked mussel powder[b]	−0.47	4.72	3.26	−7.51
Shuked shellfish powder[c]	−0.60	3.39	2.06	−4.85
Shrimp powder[b]	−6.91	4.12	1.83	0.86

[a] After 3 months storage at ambient temperature (20–26°C), [b] F–value ($P < 0.01$), [c] F–value ($P < 0.05$), [d] ——Duncan's multiple range test ($P < 0.01$), [e] ——Duncan's multiple range test ($P < 0.05$)

From the foregoing results, it can be concluded that if a selective method could be applied to the radiation sterilization of minor ingredients capable or mainly contaminating the mixed condiments, even lower doses of irradiation should be effective for the microbial control of the end products, minimizing the quality deterioration by irradiation.

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