Journal of the Korean Nuclear Society
Vol. 1, No. 1, Sept. 1969

《Original》

Radiation Preservation of Fishery Products. II.

Application of Radiation Preservation to Cure Shrimp, Common Squid and Little Squid

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(Received July 3, 1969)

Abstract

Whole cure shrimp, eviscerated common squid and little squid meats were irradiated with gamma radiation from ^{60}Co using varying dose up to one Mrad. Changes in quality were assessed by organoleptic, chemical (VRS and TMA-N), biochemical (hypoxanthine) and microbiological tests; and the effect of radiation on prolonging of the storage life at 2–4 C was studied. With the cure shrimp, 0.12–0.20 Mrad appears to be optimal with 8 days of storage life, whereas the unirradiated control samples had a storage life of 3 days. With the common squid meat, 0.20–0.30 Mrad appears to be optimal with 14–21 days of storage life, whereas the unirradiated control samples had a storage life of 8 days. And for the little squid meat, 0.12–0.20 Mrad appears to be optimal with 10 days of storage, whereas the unirradiated control samples had a storage life of 5 to 6 days.

요　　약

젓새우(*Acetes chinensis*), 피둥어꼴뚜기(*Todarodes pacificus*, 속칭 東海岸產의 오징어), 젓꼴뚜기(*Loligo beka*)를 1 Mrad까지의 각 線量의 γ線을 照射하여 이것들을 2~4°C에서 저장하여 방사선에 의한 저장효과를 시험하였다. 원료와 저장중의 魚體鮮度는 官能檢査, 화학적검사 (VRS, TMA-N 量), 생화학적검사 (Hypoxanthine 量) 및 세균학적검사 (生菌수)에 의거하여 판정하였다. VRS 값은 3魚種에 있어서 모두 관능검사치와 잘 부합되지는 않으나 TMA-N, Hypoxanthine 値 및 生菌수는 관능검사치와 잘 부합되며, 각 어종의 鮮度판정치로서 이용할수 있다. 非照射 젓새우는 3일간의 저장이 가능하나 최적선량 0.12—0.20 Mrad에서 8일간까지 저장할 수 있고, 피둥어꼴뚜기는 8일간의 저장을 최적선량 0.20—0.30 Mrad 에서 14—21일간의 저장이 가능하였으며, 젓꼴뚜기는 5—6일의 저장기간이 최적선량 0.12—0.20 Mrad에서 약 10일간의 저장이 가능하였다.

Introduction

The discovery of the ionizing radiation may be employed to destroy microorganisms and thereby extend the shelf life of food with little or no refrigeration has been subject of considerable research during the past twenty years.

The application of radiation preservation to fishery products has been exploited by Nickerson *et al.* (1950) and Procter *et al.* (1950). After that a number of studies were reported on the preservation of fishery products in the literature (Nickerson, 1954; Nickerson *et al.* 1954; Gardner and Watts, 1957; Shewan and Georgala, 1957; Shewan, 1959; Carver and Steinberg, 1959).

Since 1960, considerable technical progress has been made in research on the radiation pasteurization of sea-foods (Procte *et al.*, 1960; MacLean and Welander, 1960; Miyauchi, 1960; Shewan, 1961; Masurovsky *et al.*, 1963a, 1963b; Brooke *et al.*, 1964a, 1964b; Connors and Steinberg, 1964; Miyauchi *et al.*, 1965, National Academy of Science, 1965; Slavin *et al.*, 1965 etc.). By these works the refrigerated shelf life of many species of fish and shellfish can be significantly increased with low doses of gamma radiation, without the introduction of irradiation odors or flavours.

Slavin *et al.* (1966) and Shewan (1966) has been reviewed on the present status and future prospect on the radiation preservation of sea-foods and they concluded each that radiation pasteurization has significant economic potential for fishing industry in reducing waste and extending markets. So there can be little doubt that irradiation is a most helpful method for preserving sea-foods. It has the advantage, unlike its competitors, such as drying, salting, canning and even freezing, of retaining the properties of the fresh product, including wholesomeness.

On these results, in countries where the cold chain from catching to consumption is less effectively or not at all such as Korea, irradiation might well become an important method of preserving fish or fish products of many kinds.

The studies on radiation preservation of fishery products in Korea had been initiated by authors from 1966. Results of research on radiation effect to quality of several fishery products (small ark-shell meats, common ark-shell meats, large croaker fillets, hairtail fillets etc.) had been reported by Choe and Chung in 1966.

The objectives of present study are (1) to determine the concentrations of various chemical and biochemical constituents that formed in irradiated products during storage resulting from microbiological influence, (2) to determine the optimum conditions directed toward defining commercial process, (3) to develop physical, chemical, biochemical and microbiological tests for measuring changes in quality of fishery products treated with gamma ray.

The present works were carried out to investigate the effect of gamma radiation under various doses on storage characteristics for the cure shrimp (*Acetes chinensis*), the common squid (*Todarodes pacificus*) and the little squid (*Loligo beka*) at house hold refrigerated temperature of 2–4 C.

Materials and Methods

Source of irradiation and irradiated doses

The gamma irradiation source was the Panoramic Co-60 irradiator facility of Atomic Energy Research Institute in Korea. At the beginning of the experiments the dose-rate was 480,000 rad/h. Samples were irradiated 0 (control), 0.05—0.06, 0.10—0.12, 0.20—0.25, 0.30, 0.50, 0.75 and 1.00 Mrad for the storage test.

Preparation of sample

The cure shrimp and the little squid were obtained from local fishing grounds near Inchon, and the common squid was from the Seoul fish-market. These fresh materials were carried to the laboratory under packed in ice for irradiation. The cure shrimp was used bodily, and both the common squid and the little squid were filleted in the laboratory, and then air-packed in thin polyethylene bags, respectively. The polyethylene bags were then bended with a rubber band tightly under atmospheric conditions. The unirradiated control samples were processed similarly. After processing and irradiating at various doses, samples were held at 2—4 C in refrigerators for scheduled storage periods.

Assessment of quality

Objective methods of quality evaluation of irradiated sea-foods were performed to supplement the subjective tests. Although a number of chemcial changes are known to occur during and after irradiation, there is no an unique chemical procedure which correlates with the radiation dose or that may be used as a measure of the quality of irradiated sea-foods; organoleptic evaluation, volatile reducing substances (VRS), trimethylamine-N (TMA-N), hypoxanthine and microbiological tests were performed after storage and compared with the unirradiated materials.

1. Organoleptic evaluation

Three or four experienced judges tested for odor and color on the storage samples and graded according to a scale 1 to 9, which 9 denoted very high quality comparable to fresh fish and 5 just acceptable. Less than 5 signified that the rancid odor was pronounced that the product would be considered unsatisfactory. Adopted a 9-point scale was as follow.

9. Like extremely
8. Like very much
7. Like moderately
6. Like slightly
5. Neither like nor dislike
4. Dislike slightly
3. Dislike moderately
2. Dislike very much
1. Dislike extremely

We considered that the borderline of acceptability was reached when the score fell to 5.

2. Determination of volatile reducing substances (VRS)

VRS was determined by the modified method of Tomiyama's (1960) vapor distilled method of Strohecker (1937).

3. Trimethylamine nitrogen determination (TMA-N)

This was performed according to the modified Hashimoto and Okaichi's method (1957) of the colorimetric method of Deyer (1945).

4. Hypoxanthine determination

This was performed according to the method of precipitation as the silver salt by Jone *et al.* (1964).

5. Microbiological test

In making standard plate counts for aerobic bacteria, duplicate plate cultures were made using Medium B (Dept. of Nutrition and Food Sci., M.I.T., 1961). Medium B are contained the following constituents: BBL-Trypticase, 15.0 g/L; Phytone, 5.0 g/L; Sodium chloride, 4.0 g/L; Sodium sulfite, 0.2 g/L; L-Cystine 0.7 g/L; Dextrose, 5.5 g/L; Bacto Yeast Extract, 5.0 g/L; Agar, 15.0 g/L. The final *p*H of the medium was adjusted to 7.0 $\pm$ 0.1 and sterilized in an autoclave at 118 C for 15 minutes. Counts were made after incubating the cultures at 20 C for 5 days. Bacterial colonies were counted using a Quebec Colony Counter.

Results and Discussion

Cure shrimp

Results of the organoleptic, chemical, biochemical and microbiological tests for quality of cure shrimp meats after various intervals of storage at 2—4 C are presented in Table 1.

The unirradiated control samples had a storage life of approxmiately 4 to 5 days. After 3 days of storage, the unirradiated control samples were judged significantly lower grade in the organoleptic quality. After 7 days storage, the texture of control samples showed a sign of flaccid and slimy.

In irradiated samples, there were little effect in initial organoleptic scores following the irradiation treatment. Samples irradiated at 0.12—0.75 Mrad had a storage life of about 8 days, and the sample irradiated at 1.00 Mrad possessed a storage life of about 10 days. Irradiating at higher doses offered no apparent advantage in the extension of storage life for the cure shrimp.

The radiation odor and discoloration were barely discernible until three days storage. After three days storage, however, some radiation odor and discoloration were developed with increasing high dose levels received by the samples, which were nevertheless very apparent in the high dose samples. After 7 days storage, samples irradiated at 0.50—1.00 Mrad turned to a slight brownish color, and blackish color was also developed at the part of telson with increasing irradiated dose levels.

VRS values increased generally within the storage life in samples of unirradiated and irradiated at lower dose levels. VRS values of unirradiated fresh samples have relatively high value of 87—137 μe per

Table 1. Quality evaluation by organoleptic, chemical, biochemical and microbiological tests of the cure shrimp, irradiated at various doses and stored at 2–4 C.

Dosage (Megarad)	*Days stored at 2-4C*	*Panel score (odor)*	*Volatile reducing substances (μe/gram)*	*Trimethyl-amine (mgN/100g)*	*Hypoxanthine (mg/100g)*	*Total plate counts bacteria/gram*
0 (control)	0	9.0	136.8	0.17	9.42	2.9×10^5
	3	7.0	154.4	0.18	3.67	4.4×10^5
	8	2.0	207.0	0.74	10.88	8.1×10^5
	13	spoiled	218.0	1.58	3.47	3.4×10^7
0.06	0	9.0	113.0	0.20	11.60	1.6×10^5
	3	8.5	61.6	0.90	3.67	3.3×10^6
	8	4.5	198.0	1.58	10.88	3.9×10^7
	13	spoiled	220.0	3.50	3.47	5.1×10^7
0.12	0	9.0	115.0	0.09	11.60	1.9×10^5
	3	8.5	50.6	1.00	10.27	9.6×10^5
	8	7.5	191.8	1.70	8.95	1.2×10^7
	13	4.0	218.4	2.50	6.60	2.8×10^7
0.20	0	9.0	103.6	0.06	11.60	1.1×10^5
	8	8.5	64.0	1.20	9.86	8.1×10^3
	3	8.0	105.2	0.28	10.88	7.2×10^6
	13	4.0	109.8	0.43	3.81	2.9×10^8
0.30	0	9.0	87.0	0.14	12.17	3.3×10^4
	3	8.5	84.0	2.73	9.29	1.2×10^5
	8	8.0	105.4	2.57	11.60	5.9×10^6
	13	4.5	106.6	1.71	6.53	2.1×10^8
0.50	0	9.0	92.4	0.14	12.46	2.0×10^3
	3	8.5	64.6	0.63	10.27	0.9×10^4
	8	8.0	64.6	2.45	11.33	1.2×10^5
	13	4.5	87.0	2.00	4.52	2.9×10^7
0.75	0	9.0	108.4	0.16	12.24	1.5×10^3
	3	8.5	70.8	0.63	10.61	1.4×10^5
	8	8.5	57.6	2.48	7.78	5.0×10^3
	13	4.5	54.2	2.84	5.85	6.0×10^7
1.00	0	9.0	124.6	0.11	9.95	1.0×10^3
	3	8.5	69.8	1.31	7.80	5.0×10^3
	8	8.5	75.2	2.57	8.33	3.5×10^3
	13	5.0	44.8	2.00	3.75	1.8×10^7

gram, and rather decreased with the storage in dose levels of 0.50-1.00 Mrad. The production of VRS appears to be affected by irradiation. VRS value, therefore, does not appear to be a useful indicator of spoilage in the irradiated cure shrimp.

TMA-N values also increased generally within the storage life in both unirradiated control and irradiated samples. But TMA-N value was not possible to determine what the relation was between chemical values and organoleptic scores in the spoilage.

Hypoxanthine value also appeared to be affected by irradiation, and the value rather decreased within the storage life in the cure shrimp.

Gamma irradiation induces a considerable reduction in the number of microorganisms. Prior to irradiation the average total bacterial plate of unirradiated sample was 2.9×10^5 per gram. With high dose levels the bacterial counts were decreased remarkably. Irradiation reduced the total bacterial counts from 2.9×10^5 per gram to 1.1×10^5—1.9×10^5 per gram by radiation dose of 0.06—0.20 Mrad; to 3.3×10^4 per gram by 0.30 Mrad; to 1.0×10^3—2.0×10^3 per gram by 0.50—1.00 Mrad. Irradiated samples at dose levels of 0.75—1.00 Mrad which held for 8 days at 2—4 C showed that the bacterial count stayed below 5,000 per gram. The maximum range of bacterial counts under various irradiation doses was 3.5×10^3—1.2×10^7 per gram which was judged by the organoleptic test still to be acceptable.

By the above results the optimum radiation dose level for preservation of cure shrimp meats has been determined to be 0.12—0.20 Mrad which have the storage life of about 2-fold extension comparing with the unirradiated control samples at 2—4 C.

Common squid

Results of the organoleptic, chemical, biochemical and microbiological tests for quality of common squid meats after various intervals of storage at 2—4 C are presented in Table 2.

The unirradiated control samples at 2—4 C had a s orage life of more than 8 days but less than 10 days.

In the initial examination after irradiation, the organoleptic quality had little effect at various doses of irradiation received by the samples. The samples

Table 2. Quality evaluation by organoleptic, chemical, biochemical and microbiological tests of the common squid, irradiated at various doses and stored at 2-4 C.

Dosage (Megarad)	*Day stored at 2-4C*	*Panel score (odor)*	*Volatile reducing substances (μe/gram)*	*Trimethyl-amine (mgN/100g)*	*Hypoxanthine (mg/100g)*	*Total plate counts (bacteria/gram)*
	0	9.0	2.0	0.40	4.82	3.4×10^{6}
	3	9.0	6.6	0.50	10.88	7.7×10^{6}
0	8	8.0	31.6	1.05	12.26	1.2×10^{7}
(Control)	14	6.0	46.6	2.78	12.29	3.2×10^{7}
	21	4.5	30.4	2.80	15.35	1.5×10^{8}
	29	3.0	30.0	2.85	18.20	1.8×10^{9}
	3	9.0	3.0	0.85	8.43	6.8×10^{5}
	8	8.0	12.0	1.05	5.71	5.7×10^{5}
0.05	14	6.5	39.0	1.59	7.21	3.8×10^{6}
	21	4.5	32.2	1.85	7.50	2.9×10^{7}
	29	3.5	28.8	2.00	9.20	2.7×10^{9}
	3	9.0	5.0	0.41	4.50	2.2×10^{5}
	8	8.5	17.6	0.50	9,25	6.0×10^{5}
0.10	14	7.0	19.0	1.71	7.21	3.6×10^{6}
	21	5.0	22.0	2.27	8.50	1.9×10^{7}
	29	3.0	28.4	4.50	9.56	2.1×10^{8}
	3	9.0	5.4	0.50	4.50	2.3×10^{5}
	8	8.5	13.0	1.21	9.25	2.8×10^{5}
0.20	14	7.5	17.8	1.25	9.11	1.9×10^{6}
	21	5.0	12.6	2.27	12.35	3.6×10^{7}
	29	4.0	35.4	4.05	15.15	3.7×10^{8}
	3	9.0	6.8	0.56	7.62	1.0×10^{5}
	8	8.5	23.0	0.45	9.11	2.8×10^{5}
0.30	14	8.0	12.2	1.85	5.98	2.7×10^{6}
	21	7.0	12.6	2.21	9.56	2.5×10^{7}
	29	5.0	35.4	2.21	10.28	2.9×10^{8}
	3	9.0	9.2	0.20	5.98	0
	8	8.5	13.2	1.42	5.71	0
0.50	14	8.0	18.6	0.50	8.57	1.9×10^{5}
	21	6.0	14.0	2.75	9.25	1.5×10^{6}
	29	4.5	17.8	1.50	11.50	4.0×10^{6}
	3	9.0	3.8	0.50	9.66	0
	8	8.5	9.2	0.85	2.45	0
0.75	14	7.0	9.0	1.21	8.57	2.0×10^{6}
	21	6.5	22.6	2.50	5.67	3.9×10^{6}
	29	5.0	22.2	1.50	6.27	3.6×10^{7}
	3	9.0	3.8	0.32	1.08	0
	8	8.5	10.8	0.25	5.61	0
1.00	14	8.0	4.6	1.85	10.61	3.5×10^{5}
	21	7.5	34.2	2.89	10.88	1.7×17^{6}
	29	5.0	20.0	1.05	8.50	2.7×10^{7}

irradiated at 0.10—0.20 Mrad had a storage life of about 14 days, and irradiated at 0.30—1.00 Mrad had a storage life of about 21 days. These results showed a 1.5-fold extension at lower doses of irradiation, and 2.5-fold extension at higher doses irradiation of the storage life compare with the unirradiated ones.

The radiation odor and discoloration can be detectable treated with doses of exceeding 0.3 Mrad. Although the radiation odor was not considered objectionable with doses up to 1.00 Mrad. After 2 weeks of storage, however, the irradiated common squid meats appeared more or less yellowish color than unirradiated ones with increasing irradiation dose levels received by the samples.

VRS values, generally, increased with the time of storage in both the unirradiated and irradiated samples. The unirradiated control samples were spoiled after 14 days, by which time the VRS value had increase almost twenty-fold from the initial value of 2.0 μe per gram to 47 μe per gram, in contrast to about two to ten-fold increase in the irradiated samples. This may be irradiation of the common squid meat either reduces or alters the VRS-reducing bacterial population that little VRS is produced during the spoilage. The VRS value, therefore, does not appear to be a useful indicator of spoilage in the irradiated common squid meat.

TMA-N values also increased generally with the time of storage in both the unirradiated control and irradiated samples. The production of TMA-N does not appear to be affected by irradiation, and values of 1.6—2.9 mg per cent indicate that the common squid meat is entering to spoilage phase.

The production of hypoxanthine does not appear to be affected by irradiation, and the value increased generally with the time of storage in both the unirradiated control and irradiated samples. The hypoxanthine value of about 11 mg per cent indicate samples were either spoiled or were near the end of the storage life in the common squid meat.

Gamma irradiation produces a remakable reduction in the number of microorganism. Prior to irradiation, the total bacterial plate count was 3.4×10^6 per gram. After 3 days, bacteria increased to 7.7×10^6 per gram in the unirradiated control. Irradiation, however, reduced the total bacterial count to 0.8×10^5 per gram by radiation dose of 0.05 Mrad; to 2.2×10^5 per gram by 0.10 Mrad; to 2.3×10 per gram by 0.20 Mrad; to 1.0×10^5 per gram by 0.30 Mrad; to none by 0.50×1.00 Mrad. Irradiated samples showed only slight increases in number of bacteria until 8 days of storage. In the organoleptic test for the borderline of acceptability, the maximum range of bacteria counts under various irradiation doses were $1.7 \times 10^6 - 3.2 \times 10^6$ per gram.

By the above results the optimum radiation dose level for preservation of common squid meats have been determined to be 0.20—0.30 Mrad which have the storage life of about 2 to 2.5-fold extension compare with the unirradiated control at 2—4 C.

Little squid

Results of the organoleptic, chemical, biochemical and microbiological tests for quality of little squid meats after various intervals of storage at 2—4 C are presented in Table 3.

The unirradiated control samples at 2—4 C had a storage life of 5 to 6 days. After 10 days of storage, the organoleptic score of the control samples dropped to where the product was judged spoiled perfectly.

In the initial examination after irradiation, the organoleptic score for quality decreased slightly with increasing radiation dose received by the samples. The samples irradiated at 0.06 to 0.12 Mrad had a storage life of about 10 days, and irradiated 0.20 to 1.00 Mrad had a storage life of about 15 days. These mean a 2-fold extension at 0.06—0.12 Mrad and 3-fold extension at 0.20—1.00 Mrad irradiation of the storage life compare with the unirradiated ones.

The radiation odor was barely discernible at lower doses irradiated samples after early storage. After 2 weeks storage, the irradiated samples were turned to a slight yellow-brownish color with increasing irradiation dose levels received by the samples. And the discoloration at 0.75—1.00 Mrad treated samples were favorably distinguished from the unirradiated samples.

VRS values increased generally with the time of

Table 3. Quality evaluation by organoleptic, chemical, biochemical and microbiological tests of the little squid, irradiated at various doses and stored at 2—4 C.

Dosage (Megarad)	*Days stored at 2—4C*	*Panel score (odor)*	*Volatile reducing substances (μe/gram)*	*Trimethyl-amine (mgN/100g)*	*Hyopxanthine (mg/100g)*	*Total plate counts (bacteria/gram)*
0 (Control)	0	9.0	2.4	0.52	6.12	1.0×10^6
	5	8.0	6.2	0.71	9.14	2.3×10^6
	10	2.5	218.0	1.99	14.55	2.3×10^7
	15	2.0	221.2	2.70	12.50	3.3×10^7
	20	perfactly spoiled	230.0	2.28	5.44	2.3×10^8
0.06	5	8.0	3.8	0.94	8.23	2.9×10^5
	10	7.5	48.4	2.13	11.02	5.6×10^6
	15	3.5	211.2	2.27	15.06	2.8×10^7
	20	3.0	220.0	2.04	7.64	1.6×10^8
0.12	5	8.0	3.6	0.94	6.12	3.7×10^4
	10	7.5	21.8	2.27	9.59	3.6×10^6
	15	4.0	136.6	2.27	12.35	2.1×10^7
	20	3.5	132.8	0.28	6.12	1.3×10^8
0.20	5	8.0	3.4	1.48	7.93	4.5×10^4
	10	8.0	9.4	2.41	8.66	6.0×10^3
	15	5.5	18.0	2.13	15.12	1.8×10^6
	20	3.5	30.8	1.02	5.85	2.2×10^7
0.30	5	8.0	6.6	2.67	7.48	2.2×10^3
	10	8.0	9.4	2.47	11.02	8.1×10^4
	15	5.5	18.0	1.28	18.25	7.2×10^6
	20	4.0	31.0	0.85	5.98	1.1×10^8
0.50	5	8.5	3.8	2.41	5.44	4.0×10^3
	10	8.0	9.8	1.56	8.64	6.0×10^3
	15	5.5	14.0	1.42	15.02	5.2×10^6
	20	4.0	30.0	0.43	6.60	2.2×20^7
0.75	5	8.5	2.8	0.94	4.76	2.0×10^3
	10	8.5	11.6	2.13	8.23	4.0×10^3
	15	6.0	15.4	1.28	18.23	4.6×10^6
	20	4.0	28.8	0.74	5.85	1.2×10^7
1.00	5	8.5	11.2	0.94	8.64	0
	10	8.5	13.0	0.34	8.64	0
	15	8.0	21.0	0.57	15.25	6.1×10^4
	20	4.0	2.74	0.91	6.60	2.3×10^5

storage in both the unirradiated and irradiated samples. The production of the VRS, however, appeared to be affected by irradiation as well as common squid meats.

TMA-N values also increased with the time of storage, which does not appear to be affected by irradiation, and the values of 0.7—2.3 mg percent indicate that the little squid meat is entering to spoilage phase.

The hypoxanthine value does not appear to be affected by irradiation, and the value increased generally with the time of storage in both the unirradiated control and irradiated samples. The hypoxanthine value of about 16 mg percent indicate samples were near the end of the storage life in the little squid meat.

Prior to irradiation, the total bacterial plate count was 1.0×10^6 per gram. After 5 days bacteria increased to 2.3×10^6 per gram in the unirradiated control. At this time, however, irradiated samples reduced to total bacterial count to 2.9×10^5 per gram by radiation dose of 0.06 Mrad; to 3.7×10^4 — 4.5×10^4 per gram by 0.12–0.20 Mrad; to 2.0×10^3 — 4.0×10^3 per gram by 0.30—0.75 Mrad; to none by 1.00 Mrad. Irradiated samples showed only slight increases in number of bacteria until

10 days of storage.

In the organoletpic test for the borderline of acceptability, the maximum range of bacterial counts under various irradiation doses were $7.2 \times 10^6 - 2.3 \times 10^7$ per gram.

By the above results, 0.12—0.20 Mrad appears to be the optimum irradiation dose that extend the storage life of about 2- to 2.5-fold extension compare with the unirradiated samples at 2—4 C.

Summary

1. With the cure shrimp meat, the dose of 0.12—0.20 Mrad was found to be the optimum for inducing with good organoletpic quality and somewhat a good extension of storage life. Irradiated samples at 0.12—0.20 Mrad had a storage life of 8 days, whereas the unirradiated control samples had a storage life of 3 days.

VRS and hypoxanthine values did not correlate with the organoleptic evaluation, and the hypoxanthine value rather decreased with the life of storage. These facts suggest that the irradiation process suppress the amount of VRS and hypoxanthine produced in irradiated products as they enter the spoilage phase.

Comparatively a good correlation exist between the TMA-N value and the organoleptic evalution. The maximum range of bacterial counts under various irradiation doses were $3.5 \times 10^3 - 1.2 \times 10^7$ per gram which were judged by organoleptic test still to be acceptable.

2. With the common squid meat, 0.20—0.30 Mrad appears to be the optimum doses that made results as high-quality characteristics and significant extension of storage life at 2—4 C. The samples irradiated at 0.20—0.30 Mrad had a storage life of 14—21 days, whereas the unirradiated control samples had a storage life of 8 days.

VRS value, though increase with the storage time, does not appear to be a useful indicator of spoilage in the irradiated common squid meat. TMA-N value of 1.6—2.9 mg percent indicate that the common squid meat is entering to spoilage phase. While, the hypoxanthine value of about 11 mg percent indicated samples were either spoiled or were near the end of the storage life in the common squid meat.

In the organoleptic test for the borderline of acceptability, the maximum range of bacterial counts under various irradiation doses were $1.7 \times 10^6 - 3.2 \times 10^7$ per gram.

3. With the little squid meat, 0.12—0.20 Mrad appears to be the optimum doses that results of a product comparatively high-quality characteristics. Irradiated samples at 0.12—0.20 Mrad had a storage life of 10 days, whereas the unirradiated control samples had a storage life of 5—6 days.

VRS value does not correlate well with the organoleptic evaluation. Both TMA-N and hypoxanthine values of 0.7—2.3 mg percent and 16 mg percent serve to indicate the point of placing irradiated little squid meats on the borderline of acceptability, respectively.

In the organoleptic test for the borderline of acceptability, the maximum range of bacterial counts under various irradiation doses were $7.2 \times 10^6 - 2.3 \times 10^7$ per gram.

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