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Irradiation Preservation of Korean Fish

I. Radurization of croaker, yellow corvenia and roundnose flounder*

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방시선조사에 의한 한국산어류의 품질보존에 관한연구

I. 민어, 참조기 및 물가자미의 감마선 조사 후의 보존특성*

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민어(croaker-*Nibca imbricata*, Matsubara), 참조기(yellow corvenia-*Pseudosciaena manchurica*, Jordan and Thompson) 그리고 물가자미(roundnose flounder-*Xystrias grigorjewi*, Herzenstein) 어육을 0.5 Mrad 이하의 감마선량에 조사하여 냉장기간중의 선도 유지기간 연장을 가져오는 최적 조사선량을 구하였다. 조사된 어육을 0°와 5°C에 35일간 저장하는 동안에 일어나는 관능학적 변화를 미생물학적,화학적 변화와 비교 검토하였다.

0°C 저장을 위한 민어와 참조기의 최적선량은 0.1 Mrad였으며 5°C 저장에서는 0.2 Mrad였다. 물가자미는 방사선 조사에 대단히 민감하여 0°와 5°C 다같이 0.1 Mrad였다.

각각의 최적선량에 조사 처리하므로써 민어의 경우 0°C에서는 선도 유지기간이 비조사구의 2주간에서 5주간(3—4배)으로 연장되었으며 5°C에서는 역시 1주간 이내에서 4주간(4—5배)으로 연장이 가능하였다. 참조기는 0°C에서는 3~4배로, 5°C에서는 4—5배로 그리고 물가자미는 0°C에서 4—5배, 5°C에서 6—7배로 각각 연장되었다.

INTRODUCTION

Korea is a long, narrow penincular surrounded by highly productive marine environments and a variety of fish and shellfish are being landed throughout all seasons. For the last decade, Korean fisheries has been expending very rapidly and yearly total landing increased from approximately one half million in 1964 to two million metric tons in 1974(Annon, 1975). The present distribution systems for the fresh sea-foods, however, are such that it is estimated that 10–25% of what has been landed is being lost during the handling, transport and storage.

Application of ionization radiations to fresh fish and fishery products has received much attention in the past and it is now well established that at a dose high enough to achieve sterilization there occur adverse changes in flavor odor and appearance, rendering the irradiated products unacceptable or even harmful for human consumption (Hannan, 1955; Niven, 1958; and Coleby and Shewan, 1965). Therefore, recent emphasis has been in the application of low dose for

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extending shelf-life at refrigerated temperatures (Miyauchi *et al.*, 1965; Schultz and Lee, 1966). Many reports clearly indicated that irradiation of fresh fish or fishery products at a dose of about 0.2 Mrad would bring about a considerable extension of their keeping quality without causing any detectable change in acceptability when stored under refrigerated conditions(Connors and Steinberg, 1966; Corlett *et al.*, 1965; Emerson *et al.*, 1966; Hashish *et al.*, 1966; McLean and Walender, 1960; Masurovsky *et al.*, 1963; Kazanas *et al.*, 1966; Pelroy and Eklund, 1966; and Spinelli *et al.*, 1965.)

It is known that fish stand very well the radiation pasteurization treatment and the number of species that could be radiation pasteurized commercially is now more or less well established. Korean have contributed very little to our present-day knowledge on the subject of preservation of fish and fishery products by ionizing radiation and our effort to carry out investigation ine this field started only very recently.

This study was carried out to obtain information on the suitability of Korean marine fish for low dose application of gamma-radiation for the purpose of extending shelf-life at refrigerated temperatures.

The three species chosen for this study were croaker(*Nibea imbricata*, Matsubara), yellow corvenia(*Pseudosciaena manchurica*, Jordan and Thomson) and roundnose flounder(*Xystrias grigorjewi*, Herzenstein), and all of them are nonfatty fish, high priced, marketed mostly as fresh in either whole or filleted form and easily available along the seashore west of Seoul.

EXPERIMENTAL

General procedures

Prior to the determination of postirradiation characteristics, the minimum dose range that would bring about a significant storage life extension at 0°C and 5°C was determined for each species using the doses ranging from 0.1 to 0.5 Mrad.

Studies on the postirradiation storage characteristics of each species were then planned and carried out at 0° and 5°C using dose determined to be the optimum for each species.

Preparation of samples

The first quality fresh fish were purchased either from local wholesale dealers or at the fisheries cooperative in Inchon, some 40 km west from Seoul, where most of the coastal catch of the west coast are landed for consignment sale. The fishes so purchased were immediately gutted and well iced and transported to the Processing Laboratory of this Institue. Fish were filleted manually and the fillets cut into small cubes (approximately 0.5 in. x 1.0 in. x 0.5 in.). About 80 g of the fish meats were packed in aluminum pouch with polyethylene adjuvant(0.03+0.03mm in thickness) and the packages were heat sealed using a vacuum sealer(at 40 cm Hg by vacuum guage). Cutting the fish fillets into small cubes was necessary not only because of small size of irradiation container box, which measures 16 in. wide, 6 in. long and 9 in. high, but also because of the number of packaged samples required to cover the planned storage intervals.

Irradiation and storage

The packaged fish samples were well iced in insulated boxes and transported to the Korea Atomic Energy Research Institute to be irradiated using Brookheaven National Laboratory Mark II Ship-board Irradiator which is charged with approximately 25,000 Ci of cobalt-60. It required 51 min 5 sec to irradiate samles at 0.5 Mrad. No effort was made to maintain samples at ice temperature during the time of irradiation. Unirradiated controls were kept in ice while samples were being irradiated. After irradiation all samples were transported back to the Processing Laboratory and stored at 0°C and 5°C for subsequent studies.

Sensory evaluation

Duplicate sample packages of each group were withdrawn at storage intervals of 0, 3, 7, 14, 21, 28, and 35th day and a portion was presented to a taste panel of 5—7 judges for organoleptic rating, employing the 9-point scale system as described(Chung, *et al.*, 1976).

Objective tests

Total bacterial counts, total volatile bases (TVB), trimethylamine (TMA) and pH were measured at each sampling interval by the same methods as reported previously(Chung *et al.*, 1976). TVB and TMA contents, however, were estimated from the homogenates prepared by blending fish tissue with equal weight of 10% trichloroacetic acid instead of from the same homogenates used for total bacterial counts. By this means, detectability and reproducibility could be greatly improved.

Determination of optimum doses

The objective of this work was to determine the minimum dose range that would bring about significant storage life extension without any adverse changes in appearance, texture and odor due to irradiation rather than the maximum permissible dose.

In order to determine the optimum doses for croaker, yellow corvenia and roundnose flounder, the samples packed in aluminum pouch with polyethylene adjuvant(0.03mm+0.03mm) were irradiated at doses of 0.1, 0.2, 0.3, 0.4 and 0.5 Mrad, and stored at 0°C and 5°C respectively.

During the storage period, duplicate samples of each group were examined and the sensory evaluation given by an experienced taste panel of 5—7 judges. Total bacterial counts, total volatile bases and pH values of samples were also measured.

Although no noticeable changes were observed in general appearance and texture immediately after irradiating the samples at doses as high as 0.5 Mrad, radiation induced changes in odor were very apparent at much lower dose ranges. The croaker and yellow corvenia samples irradiated at doses above 0.2 Mrad suffered from the undesirable odor changes, which was clearly dose dependent and such odor changes were mainly responsible for the poor organoleptic scores(Fig. 1,2,3 and 4). The samples of roundnose flounder appeared to be even more radiosensitive, thus a slight irradiated odor was detected at dose of 0.1 Mrad. For this reason the roundnose flounder samples were irradiated at 0.05 Mrad, although the 0.1 Mrad flounder samples were not objectionable by the panel members(Fig. 5 and 6). On the other hand, much higher doses were reported to be permissible to other flounder species; the

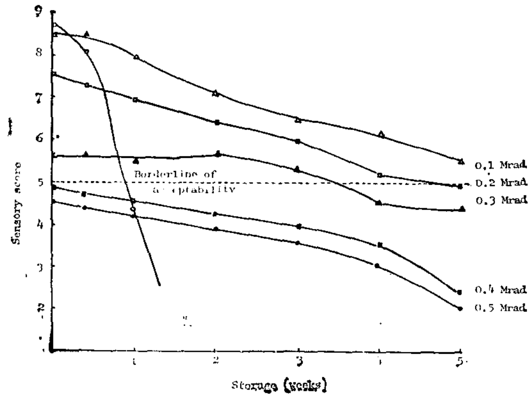

Fig. 1. Difference in sensory score of croaker fillet stored at O °C.

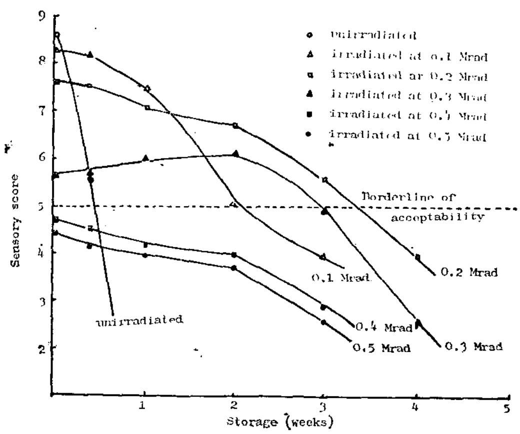

Fig. 2. Difference in sensory score of croaker fillet stored at 5 °C.

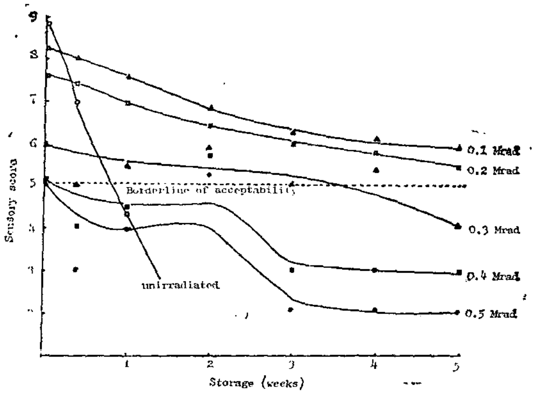

Fig. 3. Difference in sensory score of yellow corvenia fillets stored at O °C.

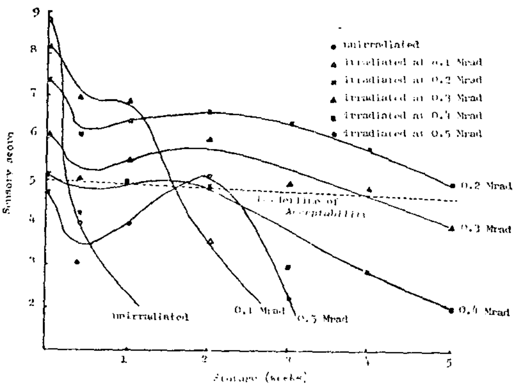

Fig. 4. Difference in sensory score of yellow corvenia fillets stored at 5 °C.

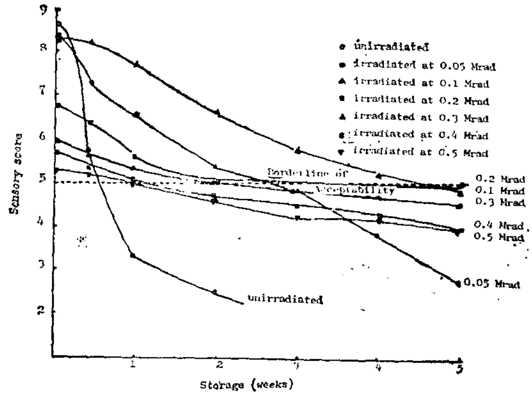

Fig. 5. Difference in sensory score of roundnose flounder fillets stored at O °C.

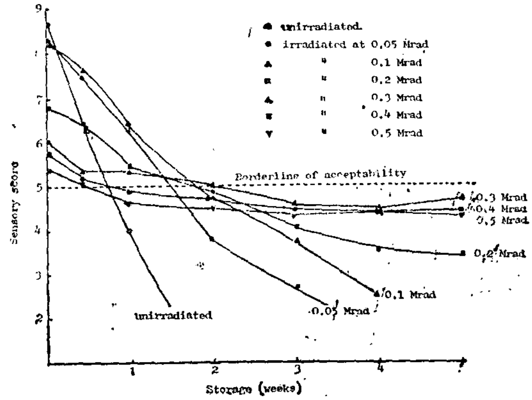

Fig. 6. Difference in sensory score of roundnose flounder fillets stored at 5 °C.

maximum permissible dose for petral sole were reported as 0. 3 Mrad(Spinelli *et al.*, 1967), that for English and petral sole 0. 4 Mrad(Miyauchi *et al.*, 1965) and that for over sole 0. 5 Mrad (Lee *et al.*, 1965). These differences were considered due to different species as shown by Shewan (1959) or to different sensory evaluation method; the sample conditions offered to the panel is different, raw, cooked or fried state, etc.

The irradiated odor, that can be described as burnt feather like or tanned odor, became progressively less upon storage and at the same time sulfur or sewage like odor developed. The same has been reported by kumta *et al.* (1970) on the Bombay duck irradiated at doses above 0. 25 Mrad.

In general, this radiation induced changes of all fish samples were mainly responsible for the poor organoleptic rating immediately after irradiation as well as during the subsequent storage and the rate of quality deterioration was invariably faster at 5°C than at 0°C as expected. This faster rate of deterioration in organoleptic quality for both irradiated and unirradiated samples stored at 5°C was reflected in the faster rate of microbial growth(Table 1, 3 and 5) and TVB accumulation(Table 2, 4 and 6) in the samples.

From the results, the optimum dose for the croaker and yellow corvenia was decided to be 0. 1 Mrad at 0°C storage and 0. 2 Mrad at 5°C, while that of the roundnose flounder 0. 1 Mrad at both 0°C and 5°C.

Table 1. Total bacterial counts of irradiated croaker fillets

a. 0°C storage (Log. No./*g* meats)

Irradiation (Mrad)	Storage (days) 0	3	7	14	21	28	35
0	5.5	6.3	7.2	8.1	8.4	8.2	8.1
0.1	4.4	5.1	5.2	5.9	7.3	7.7	7.7
0.2	3.9	4.1	4.3	5.2	6.1	6.9	7.3
0.3	3.3	3.1	3.3	4.9	5.9	6.5	6.8
0.4	2.3	2.3	2.5	4.2	5.8	6.9	7.9
0.5	—	—	2.5	3.9	6.3	7.3	7.7

— : Counts less than 50 cells per g meats

b. 5°C storage

0(Mrad)	5.5	7.0	7.8	8.0	…	…	…
0.1	4.4	5.5	7.4	7.5	7.8	7.9	8.1
0.2	3.9	4.2	5.5	6.9	6.9	7.6	8.5
0.3	3.3	3.1	5.0	6.2	6.6	7.1	8.1
0.4	2.3	2.7	5.6	6.8	8.4	8.7	8.7
0.5	—	—	4.6	5.8	8.5	…	8.7

… : No count was made
— : Counts less than 50 cells per g meats

Table 2. Total volatile base nitrogen of irradiated croaker fillets

a. 0°C storage (*mg* N/100*g* meats)

Irradiation (Mrad)	Storage (days) 0	3	7	14	21	22	35
0	12.3	—	17.0	59.5	130.0	108.5	120.2
0.1	8.2	—	8.5	6.3	19.7	—	27.7
0.2	8.2	—	10.6	6.3	10.5	11.7	10.6
0.3	10.2	—	8.5	7.4	8.5	7.4	21.3
0.4	8.2	—	9.5	5.3	6.4	7.4	10.6
0.5	6.9	—	10.6	5.3	7.4	9.5	13.8

— : Not estimated

b. 5°C slorage

0(Mrad)	12.3	—	102.1	111.7	—	12.2	—
0.1	8.2	—	10.6	44.6	39.5	57.4	67.0
0.2	8.2	—	10.6	12.7	24.8	154.2	—
0.3	10.2	—	10.6	9.5	12.7	96.8	—
0.4	8.2	—	7.4	7.4	21.2	105.3	—
0.5	6.9	—	9.5	6.3	36.1	50.3	143.6

— : Not estimated

Table 3. Total bacterial count of irradiated yellow corvenia fillets

a. 0°C Storage (Log./*g* meats)

Irradiation (Mrad)	Storage (days) 0	3	7	14	21	28	35
0	5.5	6.1	7.7	8.2	8.8	8.8	—
0.1	4.6	4.5	4.8	5.7	7.5	7.6	8.2
0.2	4.1	3.6	4.2	4.8	5.7	6.2	7.7
0.3	3.6	3.4	2.6	3.2	3.8	4.4	4.8
0.4	2.8	2.7	2.6	2.8	4.2	4.3	6.9
0.5	2.0	2.0	1.7	2.9	4.5	6.5	6.4

b. 5°C Storage

0	5.5	8.5	8.9	8.8	8.9	—	—
0.1	4.7	6.8	8.9	9.0	8.8	8.4	8.5
0.2	4.1	6.0	8.3	8.7	8.2	8.0	8.1
0.3	3.6	5.3	7.6	8.7	8.0	7.7	7.5
0.4	2.9	3.0	4.9	5.4	4.9	5.7	5.8
0.5	2.0	2.7	2.7	7.0	8.7	8.4	8.9

Table 4. Total volatile base nitrogen of irradiated yellow corvenia

a. 0°C Storage (mgN/100g meats)

radiation Ir(Mrad)	Storage (days) 0	3	7	14	21	28	35
0	6.3	17.3	26.5	82.9	94.8	100.3	—
0.1	7.4	6.8	8.2	8.2	13.7	15.5	38.3
0.2	6.9	8.2	7.3	7.3	15.5	13.7	14.6
0.3	9.0	7.3	10.0	8.2	11.9	12.8	12.8
0.4	7.9	9.1	7.3	8.2	10.0	9.1	11.9
0.5	8.5	9.1	7.3	7.3	11.8	14.6	20.1

b. 5°C Storage

0	6.4	68.4	129.5	141.3	247.1	—	—
0.1	7.4	7.3	32.8	63.8	97.5	92.2	90.2
0.2	6.9	8.2	14.5	14.5	15.5	12.8	16.4
0.3	9.1	9.1	—	13.6	13.6	13.6	14.5
0.4	7.9	8.2	9.1	10.9	12.7	12.7	—
0.5	8.5	7.3	9.1	14.5	21.8	19.1	22.8

— : not estimated

Table 5. Total bacterial counts of irradiated roundnose flounder fillets

a. 0°C Storage (Log. No./g meats)

Irradiation (Mrad)	Storage (days) 0	3	7	14	21	28	35
0	5.5	6.0	6.3	6.9	6.5	6.7	7.0
0.1	4.8	4.8	4.9	5.6	7.2	8.0	7.8
0.2	4.3	4.2	4.0	4.5	5.1	6.0	7.2
0.3	3.9	3.6	3.8	3.9	5.4	—	5.9
0.4	3.3	3.0	2.4	3.0	4.9	—	4.6
0.5	2.8	2.6	2.4	2.1	3.7	5.7	5.9

b. 5°C Storage

0	5.5	5.7	6.2	6.1	6.3	6.7	7.3
0.1	4.8	4.8	5.4	7.2	7.3	7.6	7.8
0.2	4.3	4.3	4.0	5.0	7.5	8.1	8.0
0.3	3.9	3.5	3.5	—	5.3	6.5	7.3
0.4	3.3	2.8	2.6	2.8	4.0	3.4	3.3
0.5	2.8	2.8	2.0	2.0	2.8	—	5.3

Table 6. Total volatile bases nitrogen of irradiated roundnose flounder fillets

a. 0°C Storage (mg N/100g meats)

Irradiation (Mrad)	Storage (days) 0	3	7	14	21	28	35
0	9.5	46.9	62.2	77.0	80.5	69.8	80.5
0.1	11.2	17.1	17.1	17.7	21.9	33.9	42.0
0.2	11.2	16.5	17.7	17.7	19.5	— 7.1	15.9
0.3	14.8	18.3	16.5	17.7	18.9	17.1	17.1
0.4	12.4	18.3	16.5	17.1	14.8	17.1	17.7
0.5	11.2	17.1	15.9	17.1	17.1	24.8	17.7

b. 5°C Storage

0	9.5	66.3	74.0	78.7	88.5	92.9	87.0
0.1	11.2	15.4	19.5	60.4	74.0	79.9	77.5
0.2	11.2	16.5	19.5	20.1	21.3	37.3	28.4
0.3	14.8	21.9	20.7	15.9	17.7	15.9	15.9
0.4	12.4	14.2	18.9	18.3	18.9	17.1	20.1
0.5	11.2	20.1	19.5	18.3	19.5	18.3	20.1

POSTIRRADIATION STORAGE CHARACTERISTICS

Croaker

Irradiation at doses of 0.1 and 0.2 Mrad did not bring about any noticeable chaoges in organoleptic quality except for a slight loss in fresh odor. However, by deep frying the samples the panel could not detect any differences between the irradiated and unirradiated.

The unirradiated controls became unacceptable within two weeks of storage at 0°C and one week at 5°C. By this time the samples had a slight ammoniacal and stale odor with dull and light brownish color with accompanying tissue softening. On the other hand, the samples irradiated at 0.1 Mrad and stored at 0°C could be stored as long as 5 weeks in good acceptable conditions (Fig. 7-a), while organoleptic ratings of samples irradiated at 0.2 Mrad and stored at 5°C were lower at each corresponding storage interval and became unacceptable within 5 weeks (Fig. 7—b).

During the late storage period, there started to

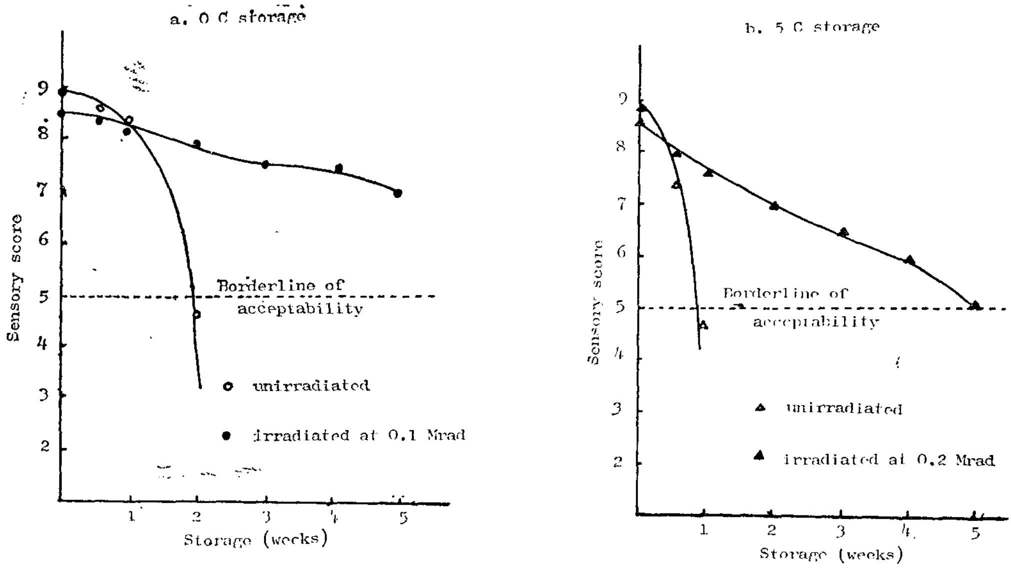

Fig. 7. Difference in sensory score of croaker fillet.

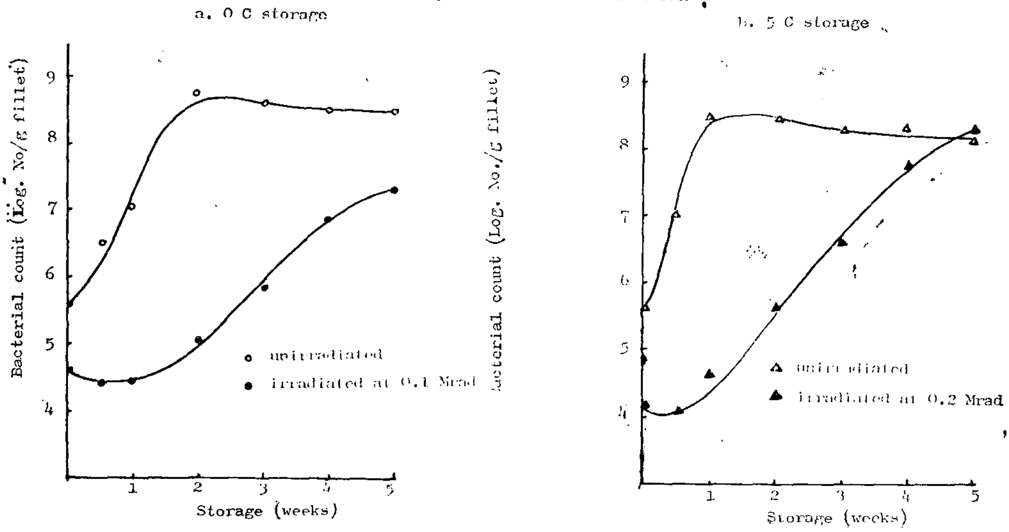

Fig. 8. Total bacterial count of croaker fillet.

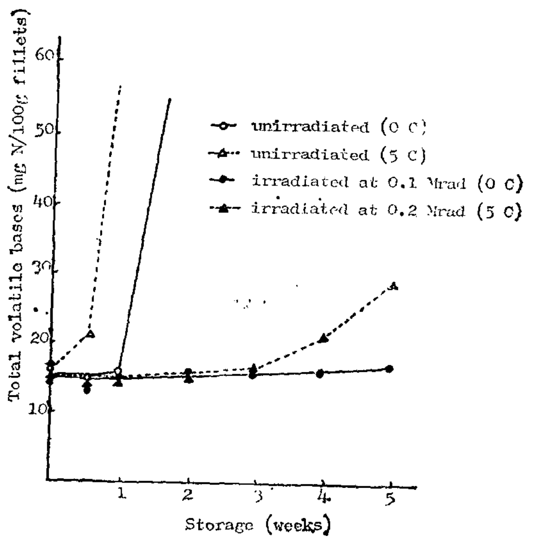

Fig. 9. Total volatile bases in croaker fillets.

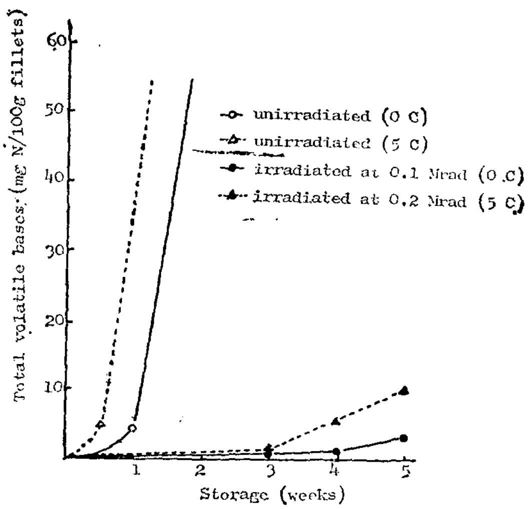

Fig. 10. Trimethylamine in croaker fillets.

develop a slight rancid odor and browning on surface in both samples and such changes were more extensive in the samples stored at 5°C.

The immediate effect of irradiating samples at 0. 1 and 0. 2 Mrad was the reduction of microflora by 10—20 folds(Fig. 8—a and b). The gap of bacterial counts between the unirradiated and irradiated became widened while the microbial growth of the unirrated was undergoing the exponential phase. During the late storage, however, the bacterial counts of the irradiated were approaching those of the unirradiated(Fig. 8—a) and for the 0. 2 Mrad irradiated samples stored at 5°C the Coants rose above those of the unirradiated

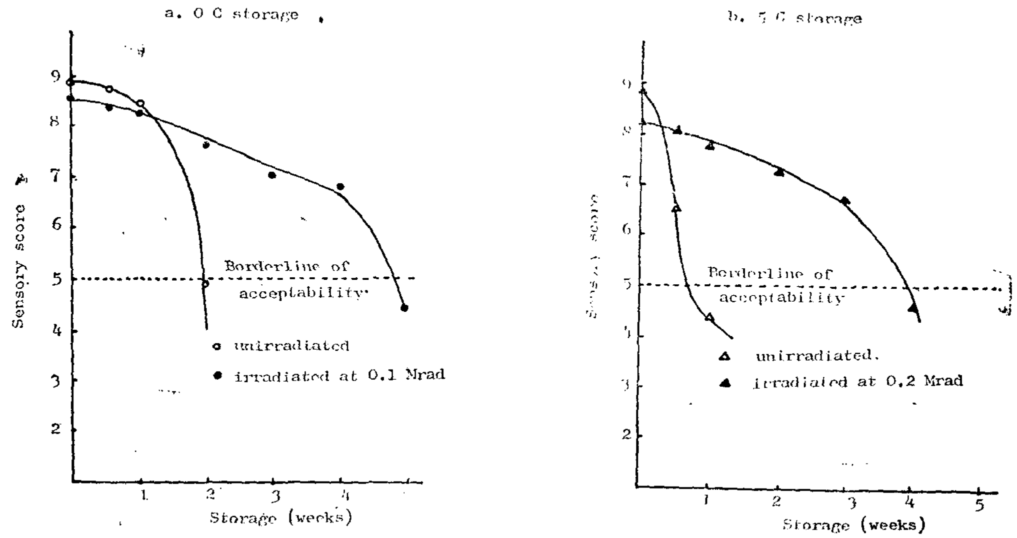

Fig. 11. Difference in sensory score of yellow corvenia fillets.

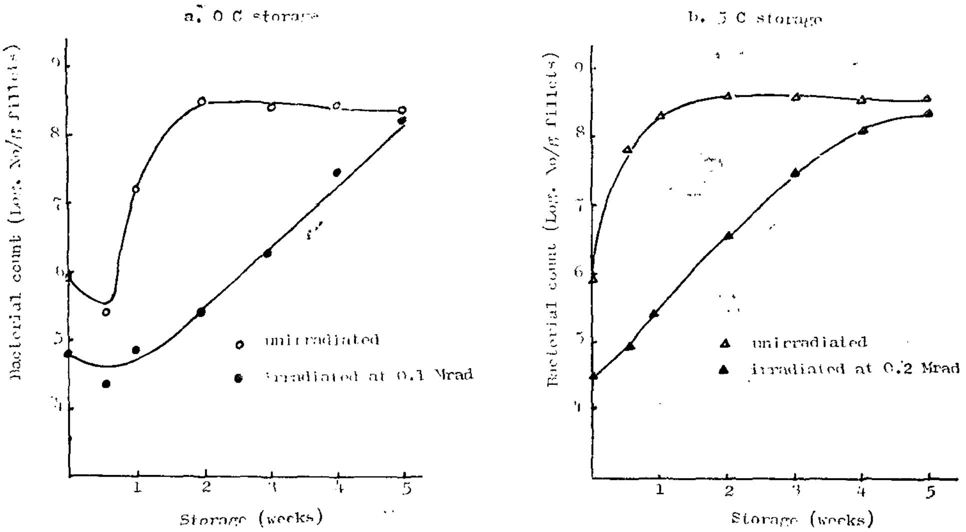

Fig. 12. Total bacterial counts of yellow corvenia fillets.

by the 5th week(Fig. 8—b).

Although the microbiological quality can be attributable to deterioration in organoleptic quality of the irradiated, particularly in late storage, it is important to note that the irradted samples were in acceptable conditions organoleptically at the cell density (10^7 or higher) which rendered the unirradiated inedible.

The effect of irradiation was well reflected in the rate of TVB and TMA accumulation; the TVB and TMA accumulation was severely suppressed in the irradiated samples, whereas that of the unirradiated proceeded very rapidly; the TVB contents increased from initially 15mgN per 100g meats to the levels above 60mgN within one week in the unirradiated and stored at 5°C and

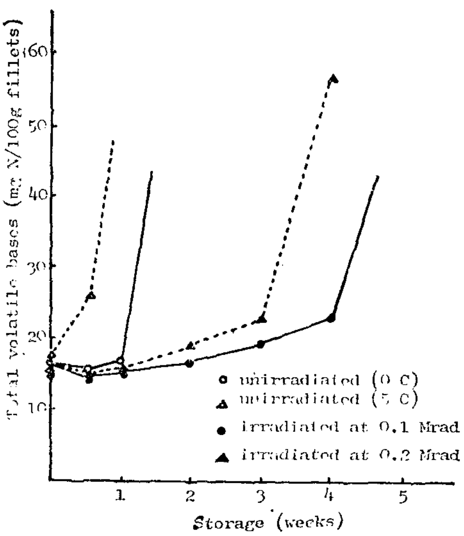

Fig. 13. Total volatile bases in yellow corvenia fillets.

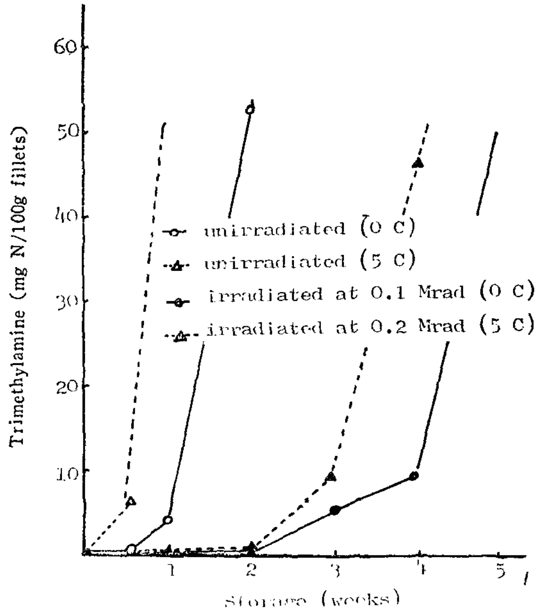

Fig. 14. Trimethylamine in yellow corvenia fillets.

that at 0°C also by the 2nd week after one week of lag period, whereas that of the irradiated started to increase after the 3rd week at 5°C, approaching the levels of 30mgN by the 5th week. The TVB contents in the samples irradiated at 0.1 Mrad and stored at 0°C remained more or less unchanged throughout the 5 weeks of storage (Fig. 9). The TMA accumulation followed a similar pattern for the TVB except that the initial values were much lower (Fig. 10).

The pronounced suppression of TVB and TMA accumulation in the irradiated samples indicates that microflora capable of producing TVB were probably selectively removed by irradiation. A similar results were obtained with shellfish samples(Chung *et al.*, 1976). This phenomenon of TVB and TMA suppression durng postirradiation storage of marine products has been well established(Masurovsky *et al.*, 1963. Pelroy *et al.*, 1967, Kumta *et al.*, 1970 and Chung, 1969).

The pH changes during postirradiation storage as shown in Table 7-a can only be related to the quality deterioration of the unirradiated and pH measurement could not be related to the quality deterioration of the irradiated fish samples,

The pH values of the unirradiated samples started to rise on the 3rd day from the initial value of 6.2, but did not exceed the values of 7.0 during 35 days of storage at both 0° and 5°C. However, there occured virtually no increase in pH values of the irradiated during the storage period at both temperatures. Thus the pH measurement could not be related to the quality deterioration of the irradiated samples.

Yellow corvenia

The storage characteristics of the yellow corvenia were very similar to those of the croaker.

The samples irradiated at 0.1 Mrad and stored at 0°C were still in good conditions at the 4th week, whereas the unirradiated became unacceptable within 2 weeks of storage(Fig. 11-a).

The quality deteriorated much faster at 5°C for both irradiated and unirradiated; the samples

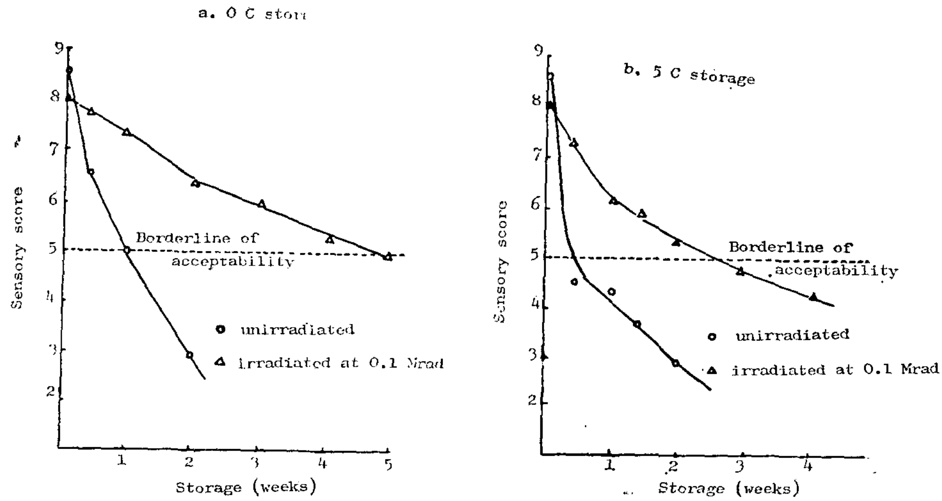

Fig. 15. Differences in sensory score of roundnose flounder fillets.

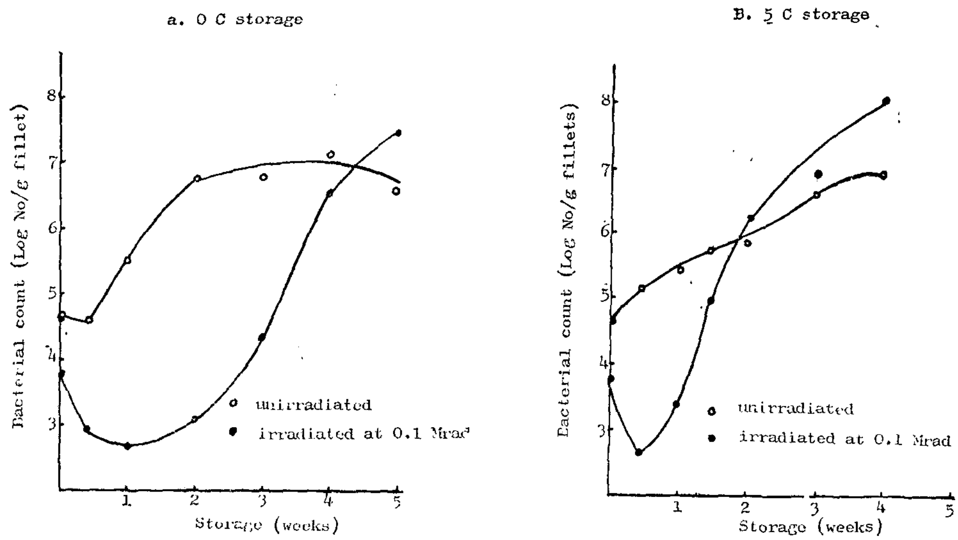

Fig. 16. Total bacterial count of roundnose flounder fillets.

irradiated at 0.2 Mrad could be held in acceptable conditions for over 3 weeks and the unirradiated controls became unacceptable within one week of storage at 5°C (Fig. 11-b).

Irradiating samples at doses of 0.1 and 0.2 Mrad resulted in 10 to 20 fold reduction of initial microflora and the microbial growth during subsequent post-irradiation storage underwent an essentially identical pattern(Fig. 12-a and b) as observed in the croaker.

The accumulation of TVB and TMA content of the irradiated was also suppressed, however, as the storage progressed, the contents started to rise rapidly, reaching the levels of the unirradiated(Fig. 13 and 14).

The TVB and TMA contents of the irradiated croaker samples did not increase appreciably throughout the 5 weeks of storage, particularly at 0°C and these differerences in the TVB and TMA accumulation observed between the croaker and yellow corvenia samples should be explainable in terms of differing qualitative aspects of microflora developing in the samples during the storage period.

The pH changes during storage relation to the sensory scores of both irradiated and unirradiated yellow corvenia samples were similar to those of the croaker.

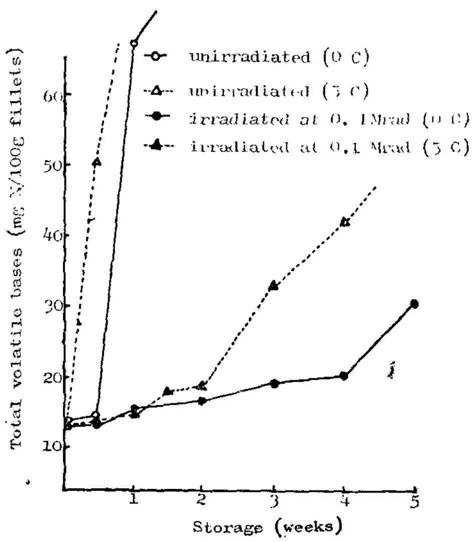

Fig. 17. Total volatile bases in roundnose flounder fillets.

Roundnose flounder

Since it appeared that the roundnose flounder meats were more radiosensitive than the two marine species tested and at the dose of 0. 05 Mrad its storage life at 0°C could be exended from 3 days for the unirradiated to 2 weeks as compared to 4 weeks for the 0. 1 Mrad irradiated (Fig. 5), a dose of 0. 1 Mrad was applied for this species at both 0° and 5°C.

By judging from sensory scores(Fig. 15), it was confirmed that by irradiating the roundnose flounder meats at o. 1 Mrad, the storage life could be extented from 3 days to 4 weeks at 0°C and from less than 3 days to up to 2 weeks at 5°C.

There resulted in an almost 10 fold reduction of microflora by irradiating the samples at 0. 1 Mrad. Unlike in the croaker and yellow corvenia, however, the total bacterial counts of the irradiated increased above those of the unirradiatd after the 4th week at 0°C (Fig. 16-a) and before the 2nd week at 5°C(Fig. 16-b).

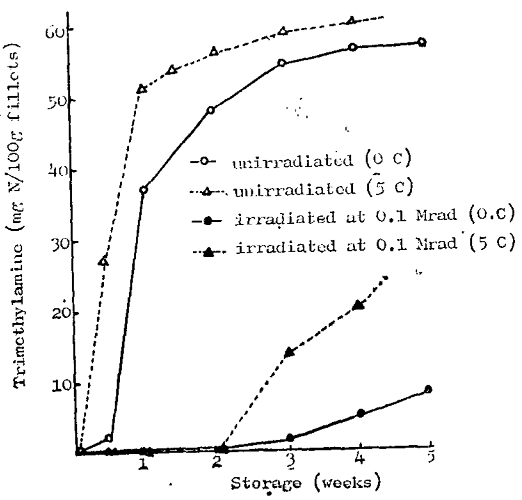

Fig. 18. Trimethylamine in roundnose flounder fillets.

The accumulation of TVB and TMA contents in the irradiated was also suppressed during the storage. However, both started to increase rapidly after the 2nd week of storage in the samples stored at 5°C. Unlike in the yellow corvenia, neither the TVB or TMA contents of the irradiated rose above the levels of the unirradiated throughout 5 weeks of storage(Fig. 17 and 18).

Again, the pattern of pH changes during the storage period was essentially identical to that of the croaker and yellow corvenia.

SUMMARY

Optimum doses

The optimum dose that may be defined as the dose below the maximum permissible dose, yet would bring about a significant storage life extension at refrigerated temperatures, varied with species of fish as well as with the postirradiation storage temperatures. Thus the dose of 0. 1 Mrad was considered to be optimum for the croaker and yellow corvenia at 0°C, while at 5°C the dose of 0. 2 Mrad would be suitable for both species. The roundnose flounder was more radiosensitive and even at the dose of 0. 1 Mrad a slight irradiation odor was detected immediately after the radiation treatment. Such degree of irradiation odor disappeared upon stoage, therefore, the dose of 0. 1 Mrad was considered to be optimum for the roundnose flounder at both 0° and 5°C.

Storage life extension

The croaker meats irradiated at 0. 1 Mrad could be held at 0°C as long as 5 weeks in good acceptable conditions, while the unirradiated control became unacceptable within 2 weeks—3-4 for extension of storage life at 0°C. At the storage temperature of 5°C, the storage life of 0. 2 Mrad irradiated samples was extended from less than one week to 4 weeks--4-5 fold extension.

The storage life extension of 0. 1 Mrad irradiated yellow corvenia at 0°C was from less than 2 weeks for the unirradiated to 4 weeks-approximately 2-3 folds and that of 0. 2 Mrad irradiated samples stored at 5°C was from 5 days to 3 weeks 4-5 folds.

The roundnose flounder meats irradiated at 0.1 Mrad could be held at 0°C for 3-4 weeks as compared to less than 1 week for the unirradiated and at 5°C the storage life could be extended from less than 3 days to up to 2 weeks. Thus the storage life extension by 4-5 folds and by 6-7 folds was possible at 0° and 5°C storage, respectively.

Postirradiation storage microbiology and biochemistry

In general 10 fold reduction of initial microflora was realized as a result of irradiating fish samples at 0.1 Mrad. The extent of microflora reduction increased with increasing doses applied, but not proportionately dependent.

The microbial growth in the irradiated was severely retarded during the subsequent storage period, lagging far behind that of the unirradiated control samples except in the late storage phase, when the levels of microflora of the irradiated either approached to or rose above the levels of the unirradiated.

The microbiological changes caused by irradiation was reflected in the pronounced suppression of TVB and TMA accumulation during the storage period. This suggests that irradiation treatment brought about both quantitative and qualitative changes in microflora initially present and it is reasonable to suggest that the microflora removed by irradiation in fact represent most of the flora capable of producing TVB and TMA in normal fish spoilage process.

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