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Radiation preservation of sea-foods : Development of dehydro-irradiation processes for shrimp (*Penaeus indicus*) and Bombay duck (*Harpodon nehereus*)

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With an annual landing of over 2,000,000 tons of fish, India ranks among the major sea-food producers in the world. Nevertheless, our country suffers from an inadequate supply of protein, particularly animal protein, in the diet. It has been estimated that meat, poultry and dairy products account for 10% of the requirements, necessitating supplementation of animal protein from sea-foods. The importance of increasing the production of sea-foods needs to be emphasized from the point of view of improving the nutrition of the population.

Fish is a highly perishable commodity, and since it is available in abundance, depending upon variety, only during a peak season which may extend from 1-3 months, it has to be readily processed. The preference in this country is for fish in fresh condition - however, inadequate supply of ice for preservation of fish, and poor transportation and distribution facilities, have resulted in fresh fish being restricted to people from coastal areas. Frozen fish is available only in negligible quantities and the freezing industry essentially caters to the export market. As regards canning, it is reported that less than 0.5% of the total marine landing is processed as canned fish (1). Freeze-drying of sea-foods is becoming increasingly popular in the advanced countries. However, this process is very expensive, and in this country, processes developed for freeze-drying sea-foods are only of academic interest. Dehydration of fish, particularly in our country, is probably the most practical method of preserving sea-foods. The major advantage of processing sea-foods by dehydration is that refrigerated conditions during transportation and storage, are not required. Moreover, because of the substantial reduction in weight, transportation and storage costs would be considerably decreased.

In our country, sun-drying is the most prominent method for dehydrating sea-foods, predominant among these being Bombay duck (Harpodon nehereus), mackerel (Rastrelliger kanagurta) and tiny shrimp (Parapenaeopsis stylifera). However, owing to the unhygienic practices prevailing during sun-drying, the final product is of very poor quality. In many cases, the dehydration is inadequate since the peak season of availability coincides with the monsoon months, and decomposition of the product is often prevented by the use of toxic chemicals.

In our laboratory, processes have been developed using combinations of heat and gamma radiation to stabilise sea-foods for preservation at ambient temperature. The sea-foods that were selected for this study were Bombay duck and shrimp (Penaeus indicus).

Bombay duck which comprises more than 10% of our annual fish catch, is not amenable to freezing and canning mainly due to the high content of free water and extreme lability of its proteins. The major portion of this sea-food is preserved using the traditional sun-drying method. However, the dried product which is commercially available is susceptible to rapid spoilage by mold, leading to impairment of quality attributes like color, flavor and texture. The dehydro-irradiation process developed in our laboratory, is capable of preserving Bombay duck laminates for a period of four months at ambient temperature.

Processing treatment for Bombay duck

Fresh Bombay duck (Harpodon nehereus) were purchased in a local market and brought to the laboratory in ice. The fish were washed clean, eviscerated and filleted. The fillets were slit open in the middle and pressed between two metal plates for 5 min. The pressure applied released tissue fluid amounting to about 20% of the fillets. Laminates thus obtained were kept in trays and steam blanched for 15 s in a steam retort. Dehydration of blanched and unblanched laminates was carried out in an air-drier at 55 to 60°C, till the moisture content was reduced to 35 - 40%. The semi-dried laminates were packed in polycell pouches and irradiated at 0.25 and 0.5 Mrad in a Co^{60} Package Irradiator (IR-11), at a dose rate of 0.24 Mrad/h. After irradiation, blanched and unblanched laminates were stored at room temperature (28 to 30°C). The flow diagram of the above process is shown in Fig.1. Table 1 indicates the ambient shelf-life of Bombay duck laminates (35 to 40% moisture) subjected to various treatments. Unirradiated samples spoilt within 4 to 8 days with heavy mold growth (10^7-10^8 molds/g) and intense ammoniacal odors, while irradiated samples were stable for 90 to 120 days. The blanching treatment which was found to enhance the storage life of unirradiated and 0.25 Mrad samples, had the added advantage of significantly retarding browning and totally inhibiting the formation of ammoniacal odors. Thus, blanched irradiated (0.25 Mrad) samples were stable at room temperature for 120 days, and showed less amount of discoloration as compared with unblanched laminates, which had a shelf-life of 90 days.

Quality of semi-dried Bombay duck laminates

Fig. 2 depicts the status of freshness indices viz: Organoleptic Score (OS), Total Volatile Basic Nitrogen (TVBN), Trimethylamine (TMA) and Total Bacterial Count (TBC) in blanched and unblanched dehydro-irradiated samples respectively. The unirradiated samples, both unblanched and blanched, spoiled rapidly (4-8 days) primarily due to heavy mold growth; hence no assessment of chemical indices was made in controls. As can be seen in Fig.2, the blanching treatment resulted in considerable reduction of TMA and TVBN values as compared with the unblanched samples. However, although TMA and TVBN are useful quality parameters for fresh sea-foods, in these studies it was observed that both unblanched and blanched dehydro-irradiated laminates had low levels of TMA and TVBN even when the samples had poor sensory ratings. These findings indicate that TMA and TVBN are poor indices of freshness of dehydro-irradiated sea-foods, which is in agreement with earlier findings from this laboratory (2,3). The absence of ammoniacal odors in the blanched irradiated samples could be attributed to the inactivation of enzyme systems which are responsible for deamination of amino acids, leading to the formation of amines and ammonia.

Extent of browning in blanched and unblanched laminates

The method for the extraction of brown pigment from Bombay duck laminates was standardized. For this purpose, fish suspensions containing different concentrations of trypsin were incubated at 45°C for 1/2, 1 and 2 h. From Table 2 it is evident that by using 60 mg trypsin in this suspension, and incubating at 45°C for 1 h, the maximum amount of pigment was extracted. Hence these conditions were used for the extraction of the brown pigment. Fig.3 shows the extent of browning in unblanched and blanched laminates exposed to 0.25 and 0.50 Mrad. The browning was more intense in unblanched laminates than in blanched ones. This suggests that certain constituents like sugars and amino acids responsible for browning, were leached out during the blanching process. Yu et al (4) observed that the leaching process alone was capable of retarding browning in radiation sterilized cod patties stored at ambient temperatures.

Rehydration ratio

Table 3 indicates that blanched laminates have better rehydration properties than unblanched ones. However, the rehydration ratios in both unblanched and blanched laminates decreased during storage at room temperature.

When semi-dried laminates are further dried to a moisture content of 5-10%, insect infestation which normally occurs during storage, can be effectively controlled by a low dose of 15 Krad.

Radiation disinfestation of sun-dried Bombay duck

Commercially sun-dried products have a good market both for inland distribution as well as for export. However, as mentioned earlier, owing to high humidity and temperature and poor storage conditions, the product is often infested with insects. Fumigation processes are not effective in eliminating the eggs, leading to subsequent deterioration of the product. A large quantity of this low-quality material is thereby wasted as manure. It was found that dried laminates packed in polycell pouches and subjected to a low dose of 20 Krad were free from insect damage for over a year. Fig.4 depicts the radiation disinfestation of dried Bombay duck laminates.

Dehydro-irradiation process for shrimp

The process described below was developed for stabilizing the storage of shrimp at ambient temperature, and to obtain a product which is superior in quality to the commercially available sun-dried products. The process integrates: 1) blanching in a 10% solution of NaCl at 80°C for 5 min to inactivate autolytic enzymes that are responsible for black spot development, 2) dip treatment in 0.5% sorbic acid for 1 h to control mold growth, 3) drying to 40% moisture level for better retention of rehydration properties, 4) sealing in polyethylene pouches to prevent contamination and 5) irradiation at 100 Krad. The reduced water activity in dehydro-irradiated shrimp checks rapid growth of bacteria during storage and maintains the total counts about 10^4/g. The combined treatments described above produce a synergistic effect resulting in a 4-6 month storage life of the product at ambient temperature. The control shrimp were found to spoil within 4 weeks.

Microbiological safety of the above processes

When food products are stored at room temperature, one has to ascertain their freedom from any microbiological hazard. *Clostridium botulinum*

Type E has been found to be the etiological agent involved in several food poisoning outbreaks in Germany, Japan, USA and other countries. Since this organism produces an extremely potent toxin, one has to ensure against the presence of this pathogen in the finished product.

Representative samples of both unirradiated and irradiated semi-dried Bombay duck laminates, as well as unirradiated and irradiated semi-dried shrimp, were not found to contain <u>C. botulinum</u> toxin during their entire storage period, as assessed by the method of Duff <u>et al</u> (6). This may be due to the low water activity of the Bombay duck laminates and the high salt concentration (3-4%) of the semi-dried shrimp. Nevertheless, to ensure the safety of these products prior to marketing, inoculated pack studies should be made (7), to examine whether <u>C. botulinum</u> Type E spores are capable of surviving the above processing treatments and producing toxin during storage of these products. In any case, since semidried products are rehydrated and then cooked, there is no botulism hazard in these products. It has been reported that the most heat resistant spores of <u>C. botulinum</u> Type E are inactivated by a factor of 10^{10} with only 20 s boiling at 100°C., and the toxins are even more heat sensitive, being destroyed after heating for 5 min at 65°C (8).

Summary

The dehydro-irradiation processes developed for Bombay duck laminates and shrimp, offer good scope for stabilizing there sea-foods at ambient temperature. The products obtained are far superior in organoleptic attributes than those prepared by the conventional sun-drying method.

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Table I

EXTENSION IN THE SHELF-LIFE OF SEMI-DRIED (35-40% MOISTURE)

BOMBAY DUCK LAMINATES WITH DIFFERENT TREATMENTS

Processing Treatment	Shelf-life at ambient temperature (Days)	Spoilage Characteristics
Unblanched, control	4 - 5	Heavy mold growth, ammoniacal odors
Unblanched, 0.25 Mrad	90 - 100	Intense browning, strong ammoniacal odors
Unblanched, 0.5 Mrad	120 - 150	Intense browning, strong ammoniacal odors
Blanched, control	7 - 8	Heavy mold growth, strong ammoniacal odors
Blanched, 0.25 Mrad	120 - 150	No discoloration, No ammoniacal odors. Acceptable
Blanched, 0.5 Mrad	120 - 150	Slight discoloration, No ammoniacal odors

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Table II

INFLUENCE OF TIME AND CONCENTRATION OF TRYPSIN ON THE EXTRACTION OF BROWN PIGMENT FROM DEHYDRO-IRRADIATED BOMBAY DUCK LAMINATES

O.D. at 400 mμ

Concentration of trypsin, (mg)	Incubation Time (hr)		
	½	1	2
20	0.13	0.17	0.17
40	0.17	0.21	0.24
60	0.20	0.25	0.25
80	0.22	0.25	0.25

Table III

REHYDRATION PROPERTIES OF UNBLANCHED AND BLANCHED DEHYDRO-IRRADIATED BOMBAY DUCK LAMINATES

Days of storage	Rehydration ratio Unblanched	Blanched
0	1.90	2.4
30	1.75	2.2
60	1.70	2.1
90	1.55	2.1
120	1.55	2.0

Rehydration ratio = $\frac{\text{Wt. of sample before rehydration}}{\text{Wt. of sample after rehydration}}$

Fig. I

FLOW DIAGRAM OF THE DEHYDRO-IRRADIATION PROCESS FOR BOMBAY DUCK LAMINATES

Bombay duck

↓

Filleting, evisceration and washing

↓

Pressing the fillets between two metal plates to form laminates

↓

Blanching in a steam retort for 15 seconds

↓

Dehydration at 55 - 60°C (Moisture content 35 - 40%)

↓

Packing in polycell pouches

↓

Irradiation (0.25 Mrad)

↓

Storage at ambient temperature (25-30°C)

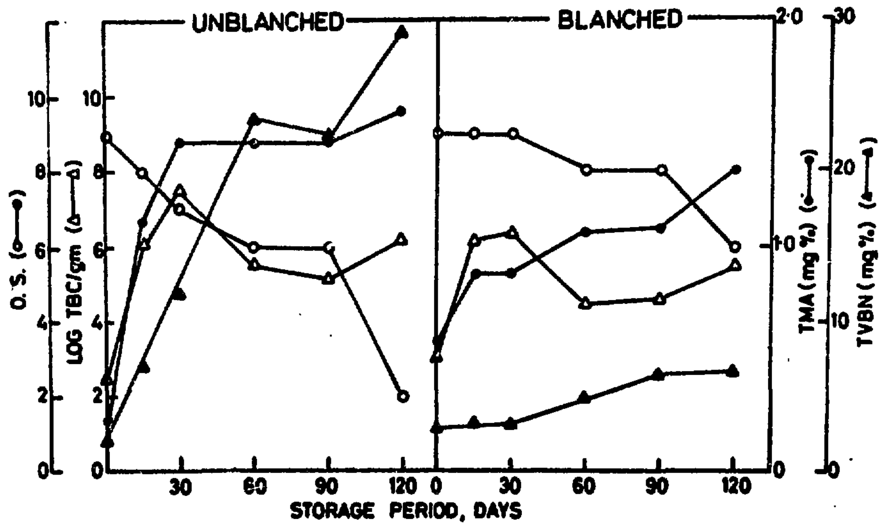

Fig.2. Effect of blanching on freshness parameters of radurised semi-dried Bombay duck laminates.

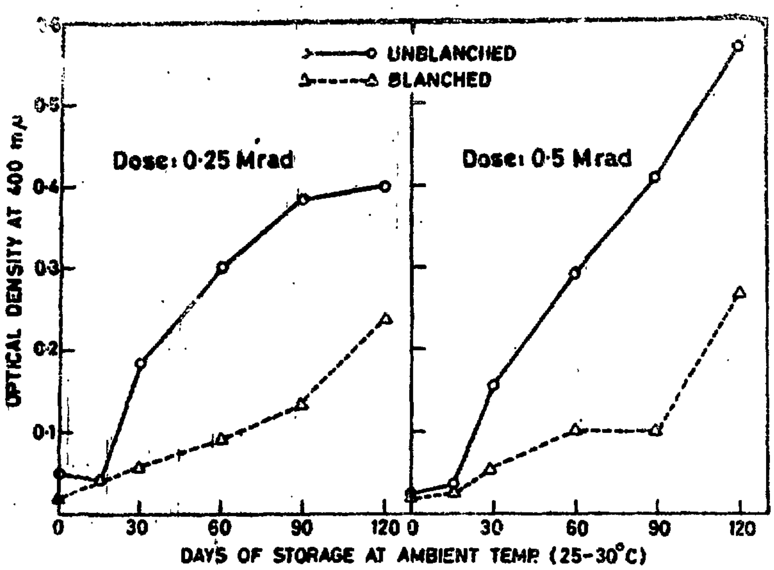

Fig.3. Effect of blanching on browning in radurised semi-dried Bombay duck laminates during storage at ambient temperature.

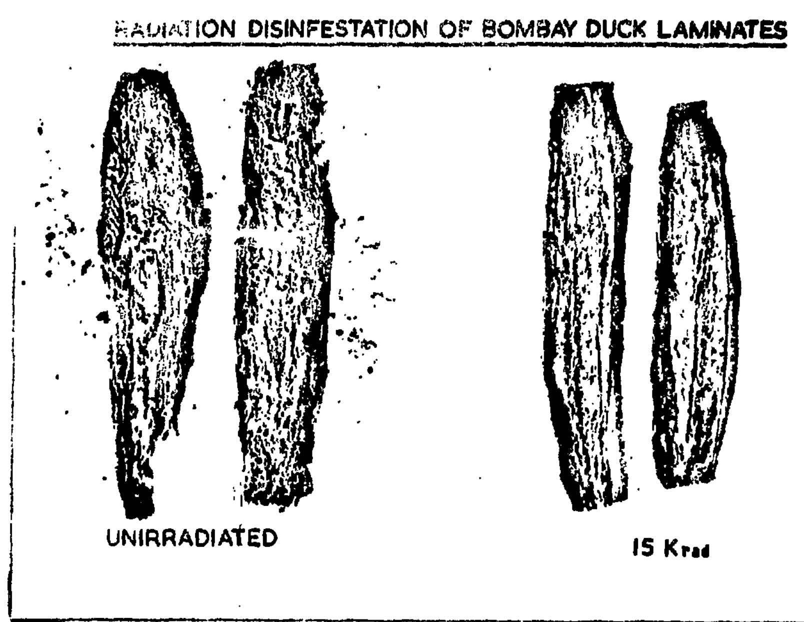

Fig. 4. Radiation disinfestation of Bombay duck laminates: Commercially available sun-dried Bombay duck laminates were packed in polythene bags (700 gauge) and irradiated (15 Krad); unirradiated laminates served as controls. Samples were examined for infestation during storage at ambient temperature.