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RESEARCH ARTICLE

SEAFOOD IRRADIATION – TECHNOLOGY AND APPLICATION.

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Abstract

Irradiation is the process by which an object is exposed to radiation. The technology of food irradiation is gaining more and more attention around the world. In comparison with heat or chemical treatment, irradiation is more effective and appropriate technology to destroy food borne pathogens. Radiation technique makes the food safer to eat by destroying bacteria which is very much similar to the process of pasteurization. Radiation does not leave the food items radioactive for two seasons. First, the gamma rays from cobalt-60 used in food radiation are not energetic enough to make it radioactive. Second, as the food never comes into contact with the source directly, it is not possible for the food to become contaminated with radioactive material. In the changing scenario of world trade, switching over to radiation processing of food assumes great importance. Radiation will be moving fast to the status of a 'wonder technology' to satisfy the sanitary and phyto sanitary requirements of the importing countries. Food once irradiated, can be prone to re-contamination unless appropriately packed. Therefore, if radiation treatment is intended to control microbiological spoilage or insect infestation, prepackaging becomes an integral part of the process.

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Introduction:-

Irradiation is the process by which an object is exposed to radiation. The exposure can originate from various sources, including natural sources. Most frequently the term refers to ionizing radiation, and to a level of radiation that will serve a specific purpose, rather than radiation exposure to normal levels of background radiation. The term irradiation usually excludes the exposure to non-ionizing radiation, such as infra-red, visible light, microwaves from cellular phones or electromagnetic waves emitted by radio and TV receivers and power supplies.

Nuclear energy has been used in several fields like agriculture in the form of radioactive tracers, medicine for radiotherapy and various industries for different beneficial purposes. One of the most recent and important uses to which nuclear energy has been successfully applied is the preservation of food materials like vegetables, fruits, tubers, food grains, meat, fish, etc. Food irradiation is a process for the treatment of food products to enhance shelf life and to improve microbial safety. Food Irradiation laboratory of Bhabha Atomic Research Center (BARC), Govt. of India, Mumbai is one of the Premier laboratories of such kind in the World. Irradiation technique developed at this center has been shown to be effective for inhibition of sprouting of potatoes and onions, delayed ripening of fruits, disinfestations of grains, extension of shelf life of fish and meat, elimination of pathogens from frozen seafood, microbial and insect decontamination of spices, etc.

The major quality problems with respect to sea foods are their contamination with microorganisms responsible for spoilage of the food and / or cause food-borne diseases to the consumers. In addition, insects and parasitic worms encountered in fish and shellfish also pose quality problems. The leading cause of sea food-borne illnesses during the last few years was Salmonellosis, followed by Shigellosis and staphylococcal intoxication. The disease causing

organisms include *Clostridium botulinum*, *Bacillus cereus*, *Campylobacter jejuni*, *Escherichia coli*, *Vibrio parahaemolyticus*, *Yersinia enterocolitica* and *Listeria monocytogenes*. The organisms present in fish causes potential hazards to people who consume fish in raw condition. Several of these organisms are capable of survive even at refrigerated temperatures, posing threat to the safety of refrigerated products. Their incidence in processed fishery products including frozen products has been of great concern in international trade of the seafood.

Irradiation appears to be a very suitable method of preservation of these high value food items. Irradiation not only reduces the total bacterial load on the fishes treated, but also shows marked selective action against some specific spoilage organisms, especially *Pseudomonas* sp. These developments will certainly improve the availability of good quality perishable foods including sea foods to millions of people across the country.

Sources of ionizing radiation:-

There are three main sources of ionizing radiation are gamma rays, electron accelerators and X-rays.

Gamma Rays:-

Gamma rays are electromagnetic radiation of a very short wave length produced by the spontaneous disintegration of the atomic nucleus of certain radioactive nuclides i.e. cobalt — 60, & cesium — 137. Both are man-made γ - rays emitting materials. Cobalt — 60 is most commonly used. Gamma rays have very high penetrating power and can, therefore, be used to irradiate bulk items like products in their final shipping container.

Accelerated Electron:-

Electron accelerators produce high — energy electron beams and accelerate them to very high speeds producing very high levels of energy in fractions of a second. Though it is quicker method, the degree of radiation penetration is poor and hence its application is limited.

X-rays:-

X-rays are produced by conversion from electron beams, but the conversion is not efficient, is uneconomic and hence not in use now.

Radiation processes:-

Radurization:-

Radurization is synonymous with pasteurization and is the irradiation process at 1 — 2 KGy levels for the extension of shelf life of fresh fishery products in ice or under refrigeration

Radicidation:-

Radicidation denotes sanitization of frozen products such as shrimp, fillets, and minced fish blocks, etc. by elimination of pathogenic microorganisms by irradiation at levels of 2 — 4 KGy.

Radappertization:-

Radappertization or radiation sterilization is analogue to thermal processing to achieve shelf-stability of processed products at ambient temperatures. The treatment requires exposing food in sealed containers to ionizing radiation at doses ranging from 25 to 70 KGy to kill all organisms to provide commercial sterility to the products.

Seafood irradiation in india:-

Irradiation has found its more proper place in urban areas where economics have shown a measure of growth and infrastructure. The potential of seafood irradiation as a means of reducing human suffering and economic losses caused by food-borne parasitic diseases and bacterial infections are greater in tropical regions. Transportation of fresh fish to the interior markets of our country poses serious problems. Application of irradiation process to preserve fresh fish can expand the marketing areas, stabilize the markets, ensure equitable distribution of the fishery products, reduce wastage and thus help in economic utilization of sea foods. According to recent information given by the Marine Products Export Development Authority, Govt. of India, the location for the country's first seafood irradiation center has narrowed down to a choice between Bhubaneswar in Orissa and Vishakhapatnam in Andhra Pradesh. The facility is expected to process close to Rs. 400 crores of seafood exports every year. The proposed irradiation plant will have a capacity to process around 10000 tonnes annually, which will result in irradiation of 2 tonnes of seafood per hour.

Fresh Fish:-

Fresh Fish has a relatively short shelf life due to microbial spoilage, enzyme action and oxidation. Irradiation at 1-2.5 KGy levels reduces the microbial spoilage and safely extends the shelf life by several days. Other spoilage mechanisms are unaffected and fish still lose quality during storage. Both marine and freshwater fish could be treated successfully. Ideally the fish should be irradiated on board the fishing vessel.

Frozen fish:-

The application of irradiation to fish in frozen condition is of special significant to our frozen fish industry. Pasteurization doses of radiation treatment after freezing could satisfactorily solve this problem.

Canned fish:-

Irradiation treatment could be used as a supplement in the canning processes. A very low dose of radiation on the canned products after usual autoclaving could ensure better sterilization of the product without affecting the other qualities.

Cured fish:-

Cured fish undergo deterioration due to infections by bacteria, fungi and insects, which get access into them in the course of processing. Irradiation at 0.5 KGy destroys the insects; *Dermestes maculatus*, *Necrobia rufipes* and members of family, *Sarcophagidae* in cured fish, but not inhibit spoilage due to mold growth.

Role of irradiation in fish preservation:-

There are three main areas where irradiation is helpful in fish preservation. They are; disinfection, extension of storage life and destruction of pathogens.

Disinfestations:-

It becomes useful in storing dried fish, by destruction of insects through radiation dose up to 1 KGy. The fish should store appropriately packed to prevent re-infestation. Parasites can also be destroyed by low doses radiation.

Extension of storage life:-

Employing doses up to 2 KGy, the number of food spoiling organisms can be significantly reduced, thus resulting in extension of shelf life.

Destruction of pathogens:-

Pathogenic bacteria like *Salmonella* and *Listeria* can be destroyed with radiation doses between 2 and 5 KGy. These doses are sufficient to destroy only viable cells; higher doses will necessary to eliminate bacterial spores' even frozen foods also.

Fish and fishery Products Recommended by the Central Committee for Food Standards for Approval

Name of the Product	Purpose	Dose (kGy)	
		Minimum	Maximum
Fresh seafoods	Shelf -life enhancement	1.0	3.0
Frozen seafoods	Pathogen control	4.0	6.0
Dried seafoods	Disinfestation	0.25	1.0

Safety of irradiated seafoods:-

With regard to the irradiated sea foods, considerations of safety for consumption involve four aspects; radiological safety, toxicological safety, microbiological safety and nutritional adequacy.

Radiological safety:

The Joint FAO/IAEA/WHO Expert Committee on the wholesomeness of irradiated food (JECFI) has recommended 10 MeV as the maximum permissible energy for electrons, 5 MeV for X-rays and 10 KGy for gamma rays. The measurement showed that no induced radioactivity could be detected in foods irradiated with 10MeV electrons at 10 KGy. But, when 20 MeV electrons were used, 0.01 Bq/g was detected on the day after irradiation. Radioactivity cannot be induced in foods unless irradiated with radiations above the threshold energy.

Toxicological safety:-

The radiation energy absorbed by irradiated foods causes various chemical reactions in the food. The chemical reactions induced by >10 KGy dose lead to about 300mg of radiolytic products per kilogram of food. Some are unique to irradiated foods and of unknown toxicity. Several studies have shown that no toxicological hazard to human health would arise from consumption of food irradiated up to an average dose of 10 KGy. No evidence of toxicological hazards associated with higher doses; however, the recommended dose is up to 10 KGy.

Microbiological safety:-

Vegetative cells are most radiation sensitive, although some bacteria viz. *Deinococcus radiodurans* and members of *Moraxella*, *Actinobacter* require comparatively higher doses for their inactivation. Low (up to 1 KGy) and medium (1-10 KGy) radiation treatments suppress the spoilage causing gram -ve organisms such as *Pseudomonas* sp., *Proteus* sp., *Aeromonas* sp., etc. Resistance to irradiation by certain bacteria such as *Micrococcus radiodurans* and *Micrococcus radiophilus* has been attributed to their unusual ability to repair the breaks in DNA caused by irradiation. Studies have shown that radiation resistance of microorganisms is influenced by treatment conditions such as temperature, presence of air, nitrogen, vacuum, etc. As compared to bacteria, viruses require higher radiation doses for their inactivation. Irradiation process appears little different to other physical processes in its microbiological changes such as mutation leading to increased resistance, enhanced pathogenicity of changed physiological traits important to their identification. In practice, the microbiological risks associated with irradiation are small.

Nutritional adequacy:-

The nature and extent of the effects of ionizing radiation on nutrients depend on the composition of food, the radiation dose and modifying factors such as temperature and presence / absence of oxygen. Irradiation up to 10KGy does not significantly alter the nutritional value of proteins, carbohydrates, minerals or saturated fats.

Proteins:-

In vitro studies have shown that free amino of proteins are sensitive to radiation. A large proportion of radiation energy deposited in an irradiated protein leads to protein denaturation, although it is much less compared with heating. Structural changes caused by the radiolytic reaction in food proteins may cause changes in functional properties such as viscosity.

Lipids:-

Radiolytic products can cause oxidation of lipids leading to rancidity. Oxidation reactions can lead to the loss of essential unsaturated fatty acids. Ozone, a strong oxidizer is produced from oxygen during food irradiation and may oxidize lipids and also myoglobin resulting in discoloration and flavor changes.

Vitamins:-

Among the vitamins, thiamine is more radiation sensitive. Other radiation sensitive vitamins are A, E, C and K. The loss of vitamins is insignificant below 1 KGy dosage. However different reports suggest that the vitamin loss caused by irradiation appears to be contradictory.

Organoleptic Changes:-

Irradiation causes only marginal changes in flavor, texture, and odor of fish. In fatty fishes, the free radicals produced as a result of irradiation can initiate autooxidation chain that will lead to rancidity. The radiation — included flavor changes, described as 'metallic', 'burnt feather — like', 'rubbery' etc. are associated with irradiated fish even when the dosage low. Some other organoleptic changes associated with sterilizing doses are brown discoloration, toughening of texture and strong bitter flavors develop in fish. Some fat — based pigments get bleached during irradiation. Integrating packaging under vacuum with irradiation can suppress bacterial spoilage and oxidative rancidity.

Packaging of irradiated fish:-

Flexible packages have special advantages and many plastic materials can be used in conjunction with irradiated foods. Ionising radiation may also be used to improve the properties of polymeric packaging materials and inactivate any microorganisms, with the packing material might have been contaminated with prior to bringing into contact with the food. In contact with food, extractives from the package should not contaminate the food. The packaging material does not get itself irradiated and induce radioactivity in the food contained.

Legal aspects and public health:-

Governments all over the world have the responsibility to control irradiation processing of food. The International Consultative Group on Food Irradiation (ICGFI) which was established by the International Organizations such as WHO, FAO, IAEA, has issued guidelines for preparing regulations to control food irradiation facilities. Any new method of preservation has necessarily to ensure that no toxic substances are produced due to the process and the foods preserved by such methods should not exhibit deleterious effects of any sort on the health of the consumer. Doubts about risk of induced radioactivity in such foods have been expressed at times. No report of formation of harmful toxic substances is available, even though peroxides are formed to some extent in fatty foods during irradiation. No evidence of development of carcinogenicity in such foods has yet been put forth. The irradiation processing has to be used only as a supplement and should never form substitute for good hygienic practices because it depends upon the initial quality of the raw material.

Foods that have been irradiated must be labeled with green international logo to inform that the food has been processed by ionizing radiation. The words "Treated with radiation" or "Treated by irradiation" must be in the same print style as the product name and be no smaller than one-third the size of the largest letter in product name.

Conclusion:-

Thus, it can be concluded that exposure of fishery products to ionizing radiation could effectively eliminate or reduce the pathogens of public health significance, spoilage causing microorganisms, insects and parasites while maintaining wholesomeness and sensory quality of the seafood. Such technology is more useful for the countries like India to meet the nutritional demands of huge population, as fish is a cheap animal protein source with high essential amino acids as well as with health beneficial omega — 3 polyunsaturated fatty acids.

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