FOOD IRRADIATION - A VIABLE TECHNOLOGY FOR REDUCING POST HARVEST LOSSES OF FOOD*

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ABSTRACT

Research and development in the past 30 years have clearly demonstrated that food irradiation is a safe, effective and environmentally clean process of food preservation. Twenty-seven countries have approved over 40 irradiated foods or groups of related food items for human consumption, either on an unconditional or a restricted basis. The technology is beginning to play an important role in reducing post-harvest losses of food and in facilitating wider distribution of food in the trade. Its wide application in solving microbial spoilage losses of food, insect disinfestation, improving hygienic qualities, slowing down physiological processes of foods is reviewed. Special emphasis is placed on applications of direct relevance to countries in Asia and the Pacific region.

INTRODUCTION

The increasing awareness of the need to reduce post-harvest losses of food may be illustrated by a resolution of the seventh special session of the United Nations General Assembly, adopted in September 1975, which stated that "the further reduction of post-harvest food losses in developing countries should be undertaken as a matter of priority with a view to reaching at least 50% reduction by 1985". Thus, every safe and effective method for combating food losses must be used to make more food available for mankind.

Food irradiation is gaining wider recognition and acceptance as a physical process of food preservation. In principle, this process involves exposing food either prepackaged or in bulk, in cans or in the dried or frozen state, to ionizing energy in the form of X-rays, gamma rays or electrons in a special room for a specified duration. At present, the most common source of ionizing energy for treating food and non-food products is ^{60}Co and, to a lesser extent, ^{137}Cs , which are so-called "radioisotope" sources. There are also "machine" sources, which can generate electrons or X-rays for food treatment. It is important to note that exposing foods or any material to ionizing energy from either ^{60}Co or ^{137}Cs or electrons (10 MeV maximum energy), or X-rays (5 MeV maximum energy), does not induce radioactivity in the materials treated, even at a radiation dose a thousand times greater than the highest dose contemplated for food preservation.

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In general, the application of food irradiation may be summarized as follows:—

Low dose	(up to 1 kilogray)
(a)	inhibition of sprouting
(b)	insect disinfestation
(c)	delay of ripening
Medium dose	(1 – 10 kilogray)
(a)	extension of food shelf-life
(b)	reduction of microbial load
(c)	improvements of technological properties of food
High dose	(10 – 50 kilogray)
(a)	commercial sterilization
(b)	elimination of viruses.

SAFETY AND ACCEPTANCE OF IRRADIATED FOODS

The safety of food treated by ionizing energy was evaluated by several expert committees appointed by FAO, IAEA and WHO since 1964. The latest Joint FAO/IAEA/WHO Expert Committee on the Wholesomeness of Irradiated Food (JECFI), convened in 1980, concluded that ionizing energy treatment of food commodities with an overall average dose of 10 kilogray or 1 Mrad caused no toxicological hazard for human consumption (FAO/IAEA/WHO 1981). This conclusion, as well as other recommendations of JECFI, were introduced into the system of the Codex Alimentarius Commission (CAC) with a view to establishing an international standard for irradiated foods. After elaboration under the Codex procedures, CAC decided to adopt a "Codex General Standard for Irradiated Foods" (treated up to an overall average dose of 10 kilogray), and a "Recommended International Code of Practice for the Operation of Radiation Facilities Used for the Treatment of Foods", at its 15th session held in July 1983 (Codex Alimentarius Commission, 1984). The Codex Standard and Code of Practice have already been circulated to all member countries of the CAC for acceptance.

Following the above developments, national authorities have shown positive attitudes towards food irradiation processing. At present, 27 countries have approved collectively over 40 irradiated food items for human consumption, either on an unconditional or restricted basis. Countries such as Australia, Bangladesh, Canada, Chile, Denmark, England, France, Netherlands, USA and Yugoslavia have initiated steps to approve food irradiation as a process of food preservation, up to a certain maximum dose.

SPECIFIC APPLICATIONS OF FOOD IRRADIATION OF INTEREST TO COUNTRIES IN ASIA AND THE PACIFIC

1. A Substitute for Chemical Fumigation

Fumigation of food and food ingredients with various chemicals such as ethylene dibromide (EDB), methyl bromide (MB), ethylene oxide (ETO), etc., has been held suspect by health authorities, from both the health and occupational safety points of view. In the USA, the use of EDB as a food fumigant was banned by the Environmental Protection Agency as of 1 September 1984 except for treating fruits destined for export (Anon, 1983). Any food treated with EDB is also prohibited for sale in the USA, with the exception of mangoes, which is still permitted until 1 September 1985. The ban of EDB has deprived the fruit and vegetable industry in the USA of a strong and broad spectrum

fumigant commonly used for overcoming quarantine restrictions against fruit fly infestation of these products.

Irradiation can be used instead of chemical fumigation in the following areas:

1.1. A quarantine treatment for fruits and vegetables

Without EDB, other fumigants such as MB and phosphine do not offer a broad spectrum for treating fruits and vegetables. Physical processes such as cold storage and heat treatment which are capable of insect disinfestation of fruits and vegetables also have limitations. Irradiation appears to offer the most viable alternative for this purpose. The irradiation dose required for fruit fly disinfestation to satisfy quarantine regulations (0.25 kilogray) does not change physico-chemical and organoleptic properties of most fruits and vegetables. A dose as low as 0.1 kilogray would prevent eggs of most fruit fly species from developing into adults (Burditt, 1982).

1.2 A physical method for insect disinfestation of stored products

The safety of methyl bromide, the most widely used fumigant for insect disinfestation of food grain and other stored products, appears to be in doubt. At best, methyl bromide fumigation could provide a short term solution to overcome infestation problems. In addition, insects are capable of developing resistance to most chemicals. Irradiation offers a good potential to replace MB fumigation whenever the use of this chemical is prohibited. A radiation dose of between 0.25 and 0.50 kilogray is sufficient for disinfestation of most, if not all, species of stored-product insects. Already, two large electron accelerators have been in operation for insect disinfestation of imported food grain at Port Odessa, USSR, since 1980. Each machine (1.4 MeV, 20 kW) is capable of treating an average of 200 tons of grain per hour at a dose of between 0.20 and 0.40 kilogray (Zakladnoi, et al., 1982). Calculation of the technoeconomic characteristics of radiation aided disinfestation and fumigation with methyl bromide shows the former method to be more economical, especially when disinfesting grain unloaded from ships, given an annual volume of 400,000 – 500,000 tons.

1.3 A method for decontamination of spices and other food ingredients

Spices and other food ingredients destined for incorporation into processed foods such as canned meat, sausages, soup, etc., have to comply with certain microbiological specifications. Up to now, ethylene oxide (ETO) has been generally used for microbial decontamination of these products. The use of ETO appears to be limited in the near future in view of the increasing regulatory restrictions in Europe, Japan and the USA. Irradiation with a dose up to 10 kilogray provides the most viable alternative to ETO fumigation of spices and other food ingredients. The use of irradiation to decontaminate spices and other food ingredients is being carried out on a commercial scale in Belgium, France, Hungary, the Netherlands and the USA.

2. Disinfestation and Decontamination of Fishery Products

Countries in Asia and the Pacific are the major producers and exporters of fishery products. Irradiation offers potentials in the following applications for these products:

2.2 Insect disinfestation of dried and cured fish

Dried and cured fish are normally infested by insects of several species, both during sun-drying and storage. In some countries, the use of insecticides to disinfest insects in these products is still being practiced. Such use is meant to reduce high losses caused by insect infestation without giving much consideration to health impli-

cations for the consumer. Irradiation with a dose up to 0.5 kilogray is effective for insect disinfestation of dried and cured fish (Anon, 1978). If properly packaged, irradiated dried and cured fish can be kept insect-free at room temperature for several months.

2.2 Elimination of certain pathogens in frozen seafood

Fish and shellfish caught in polluted water and/or subjected to human handling during processing are occasionally contaminated by *Salmonella*. In the case of frog legs, *Salmonella* contamination is quite common as live frogs normally live in polluted environments. Chlorination and freezing of these products cannot eliminate *Salmonella* completely from these processed products. Irradiation offers an ideal solution for the elimination of this pathogen and the product can be treated even in a frozen condition. A dose of between 3 and 5 kilogray would eliminate a minimum of 6 log cycles of all serotypes of *Salmonella* in frozen seafood and frog legs without causing an adverse effect on the quality (Tambunan, 1984). Commercial scale irradiation of frozen seafood and frog legs is being carried out in Belgium and the Netherlands.

3. Sprout Inhibition of Root Crops

Certain root crops such as potatoes, onions and garlic undergo physiological deterioration in addition to being attacked by microorganisms during storage. Among the losses due to physiological factors, sprouting is the most important cause of deterioration (Thomas, 1983, 1984). In countries where ambient temperatures are high, sprouting of root crops occurs much earlier than in temperate or cold countries. In addition, chemical sprout inhibitors are not effective under tropical conditions.

Irradiation with a dose of 0.1 kilogray is effective for sprout inhibition of all root crops provided that the treatment is carried out when they are in the dormant state (within one month after harvesting). Certain root crops such as potatoes should be cured, irradiated and stored in the same container to minimize handling damages during the following irradiation. Irradiated potatoes should be stored at approximately 10°C to reduce losses caused by spoilage microorganisms.

COMMERCIALIZATION OF IRRADIATED FOODS

The number of countries which commercialize irradiated food is growing. Following the first successful commercial facility for irradiating potatoes built by Shihoro Agricultural Cooperative in Hokkaido, Japan in 1973, other countries such as Belgium, the Netherlands, South Africa and the USA have used their commercial irradiators designed mainly for sterilizing disposable medical products for treating food and food ingredients as well. Irradiators which are available for treating food or feed on a commercial scale in different countries are listed in Table 1. Recently, countries such as France, Hungary, Italy, South Africa and the USA have constructed or are constructing irradiation facilities solely for treating foods. The irradiators which are being constructed or are planned for treating food/feed on a commercial scale are listed in Table 2. Developing countries such as Bangladesh, the People's Republic of China, the Republic of Korea, Mexico, Pakistan and Thailand are either considering or are planning the commercialization of food irradiation processing in the near future.

TABLE 1: COMMERCIAL IRRADIATORS AVAILABLE FOR TREATING FOOD/FEED

Country	Commercial Irradiator Location	Status	Products Treated	Approx. Capacity
BELGIUM	MEDIRIS* Fleurus	completed (1980)	spices, animal feed, frozen seafood	3,000 tons/year
BRAZIL	EMBRARAD* Sao Paulo	completed	spices	---
CHINA, PEOPLE'S REP.	Multipurpose irradiator (180 kCi) Chengdu	completed	---	---
	Multipurpose irradiator (100 kCi) Shanghai	completed	---	---
ISRAEL	Animal Feed Irradiator (accelerator) Tel Aviv	completed (1984)	animal feed	---
JAPAN	Shihoro Potato Irradiator Shihoro, Hokkaido	completed (1973)	potatoes	15,000 tons/month
NETHERLANDS	Pilot Plant for Food Irradiation Wageningen	completed (1968)	shrimp, frog legs, organic dyes, spices	1,500 tons/year
	GAMMASTER-1* Ede	completed (1972)	spices, frozen frog legs, shrimp	5,000 tons/year
	GAMMASTER-2 Multipurpose Ede	completed (1982)	spices, frozen frog legs, shrimp	5,000 tons/year
SOUTH AFRICA	Fruit & Vegetable Irradiator Tzaneen	completed (1982)	mangoes, strawberries, potatoes, onions, etc.	7,000 tons/year
	Tso-Ster (Pty.), Ltd.* Kempton Park	completed (1981)	fruits, vegetables, coconut powder	---
	Multipurpose Irradiator Atomic Energy Board, Pretoria	completed	fruits, vegetables, chicken, etc.	---

TABLE 1 (continued)

Country	Commercial Irradiator Location	Status	Products Treated	Approx. Capacity
TAIWAN	Multipurpose Irradiator	completed	---	---
USA	Radiation Technology, Inc. Rockaway, New Jersey	completed (few irradiators)	spices, seasonings	500 tons/year
	Isomedix, Inc. Whippany, New York	completed (several irradiators)	spices, seasonings	500 tons/year
	International Nutronics Irvine, California	completed (several irradiators)	spices, seasonings	500 tons/year
USSR	Grain irradiators (two electron accelerators) Port Odessa	completed (1981)	grain	400,000 tons/year

*Mainly used for sterilizing medical supplies

TABLE 2: COMMERCIAL IRRADIATORS PLANNED FOR TREATING FOOD/FEED (January 1985)

Country	Commercial Irradiator Location	Status	Products Treated	Approx. Capacity
BANGLADESH	Multipurpose irradiator (150 kCi) Dhaka	planned for 1985	potatoes, onions, fish	---
CHINA, PEOPLE'S REP.	Multipurpose irradiator (200 kCi) Shanghai	under construction	food in general	---
ECI ADOR	Electron accelerator Quito	under construction	dried food	---
FRANCE	Pallet irradiator (2 million kCi 60Co) Marseilles	planned for 1985	food in general	---
HUNGARY	CGR 10 MeV accelerator	planned for 1985	deboned poultry	---
IRAN	AGROSTER Joint Co. Budapest	planned for 1985	spices, potatoes, onions	---
ITALY	Multipurpose irradiator Tehran	planned for 1986	dried food	---
KOREA (REPUBLIC OF)	Commercial Vegetable Irradiator Fucino Cooperative, Fucino	under construction	potatoes, onions, garlic	25,000 tons/season
PAKISTAN	Multipurpose irradiator Seoul	under construction	food in general	---
THAILAND	Multipurpose irradiator Karachi	planned for 1986	food in general	---
USA	Multipurpose irradiator (200 kCi) Bangkok	planned for 1986	food in general	---
	International Nutronics Honolulu, Hawaii	planned for 1985	tropical fruit	---

CONCLUSIONS

After more than three decades of research and development, food irradiation has been shown to be a safe and viable technology for reducing post-harvest losses of food. Its broad spectrum could solve the problems of spoilage losses of food items of economic significance to developing countries as well as overcoming certain barriers in international trade of food. At a time when a portion of the population is still facing hunger and malnutrition, food irradiation provides another viable tool to combat the high rate of food losses in developing countries and to make more food available to mankind.

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