International Developments of Food Irradiation

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Introduction

Food irradiation is increasingly accepted and applied in many countries in the past decade. Through its use, food losses and food-borne diseases can be reduced significantly, and wider trade in many food items can be facilitated.

The past five decades have witnessed a positive evolution on food irradiation according to the following:

1940's: discovery of principles of food irradiation

1950's: initiation of research in advanced countries

1960's: research and development were intensified in some advanced and developing countries

1970's: proof of wholesomeness of irradiated foods

1980's: establishment of national regulations

1990's: commercialization and international trade

Development of national regulations

A major milestone on food irradiation occurred in 1980 when the Joint FAO/IAEA/WHO Expert Committee on the Wholesomeness of Irradiated Foods (JECFI) concluded that 'irradiation of any food commodity up to an overall average dose of 10 kGy causes no toxicological hazard; thus, toxicological testing of food so treated is no longer required'. The JECFI also stated that irradiation of food up to 10 kGy introduces no special nutritional and microbiological problems. In subsequent years, a number of national and regional authorities convened their own expert committees independently to evaluate data on wholesomeness of irradiated food. All these committees arrived at a similar conclusions as the JECFI. The conclusions and recommendations of the 1980 JECFI were elaborated into international

standard under the procedures of the Codex Alimentarius Commission (CAC) of the Joint FAO/WHO Food Standards Programme. The CAC has its primary objectives in protecting consumer health and ensuring fair practice in the food trade. The procedures of the CAC require several rounds of governments' comments. In 1983, the CAC then represented by some 130 governments, decided to adopt a Codex General Standard for Irradiated Foods and a Recommended International Code of Practice for Operation of Radiation Facilities Used for Treatment of Food. The Codex Standard was recommended by the CAC to all its member governments for acceptance in 1984.

The Codex Standard provides important incentives for national authorities to introduce regulations on food irradiation. In fact, starting from the early 1980's, several advanced countries including Canada, Denmark, France, the Netherlands, U.K., USA, etc., and many developing countries including Bangladesh, Brazil, Chile, China, India, Republic of Korea, Mexico, Thailand, etc. have introduced their regulations on food irradiation following the principles of the Codex Standard. In doing so, several countries invited public comments prior to finalizing their national regulations. Such action led to wide public debates concerning the safety and necessity of irradiated food. A number of pressure groups emerged from essentially 'middle of no-where' to oppose the use of this technology. Most governments have, however, recognized the safety and benefits of food irradiation and decided to introduced regulations on this subject. Currently, some 40 countries have approved the use of food irradiation for over 100 food items or groups of food, either on an unconditional or restricted basis.

With increasing interest in using irradiation to sterilize a number of food products to render them shelf-stable for specific populations (hospital diets, immuno-compromised population, food for specific recreation/sport activities, armed forces) and to increase the availability and variety of shelf-stable foods for the general public, FAO, IAEA and WHO convened a Joint Study Group on the Wholesomeness of Food Irradiated with Doses above 10 kGy in Geneva, Switzerland, 15-20 September 1997. After considering data on toxicological, nutritional, microbiological and radiation chemistry aspects of food irradiated with doses above 10 kGy, the Joint Study Group concluded that food irradiated under proper conditions appropriate to the intended technological objectives, is safe to consume and adequate for nutrition. Food irradiation is therefore deemed to be wholesome for all technological dose range either below or above 10 kGy.

The conclusions of the Joint Study Group will have to be elaborated under the Codex procedures with a view to amend the existing Codex General Standard for Irradiated Foods. Once the Codex Standard has been revised, national authorities will be invited to considered accepting irradiation as a process for treating food without a maximum dose. Such a consideration is in line with other physical food processes, e.g. heating or freezing preservation of food, which also has no maximum or minimum limit relative to their applications.

Commercial application of food irradiation

Following the success in using irradiation commercially to inhibit sprouting of potatoes in Japan in 1973, several countries have recognized the benefit of using this technology on a commercial scale to combat food losses and ensure hygienic quality of food. Since then, the number of countries which use irradiation for processing food for various commercial purposes has increased steadily to 29 at present (Table I). The majority of the increase in recent years is in developing countries which either need irradiated products for their domestic market or seeing an opportunity to develop markets overseas.

Table 1
COMMERCIAL ACTIVITIES ON FOOD IRRADIATION
(As of July 1997)

Country	**Location** (starting date for food irradiation)	**Products**
Algeria	*Mascara*	Potatoes
Argentina	Buenos Aires (1986)	Spices, spinach, cocoa powder
Bangladesh	Chittagong (1993)	Potatoes, onions, dried fish
Belgium	Fleurus (1981)	Spices, dehydrated vegetables, deep frozen foods
Brazil	Sào Paulo (1985) *Piracicaba* *Manaus*	Spices, dehydrated vegetables Fruits, vegetables, grain
Canada	Laval (1989)	Spices
Chile	Santiago (1983)	Spices, dehydrated vegetables, onions, potatoes, poultry meat
China	Chengdu (1978) Shanghai (1986) Zhengzhou (1986) Nanjing (1987) Jinan (1987) Lanzhou (1988) Beijing (1988) Tienjin (1988) Daqing (1988) Jianou (1991) Beijing (1995)	Spices and vegetable seasonings, Chinese sausage, garlic. Apple, potatoes, onions, garlic, dehydrated vegetables Garlic, seasonings, sauces Tomatoes Not specified Not specified Not specified Not specified Not specified Not specified Rice, garlic, spices
Croatia	Zagreb (1985)	Spices, food ingredients, dried beef noodles
Czech Rep.	Prague (1993)	Spices, dry food ingredients
Cuba	Havana (1987)	Potatoes, onions, beans
Denmark	Riso* (1986)	Spices
Finland	Ilomantsi (1986)	Spices
France	Lyon (1982) Paris (1986) Nice (1986) Vannes* (1987) Marseille (1989)	Spices Spices, vegetable seasonings Spices/herbs Poultry (frozen deboned chicken) Spices, vegetable seasonings, dried fruit, frozen frog legs, shrimp, poultry (frozen deboned chicken).
Germany	Munich (1997)	Spices
Hungary	Budapest (1982)	Spices, onions, wine cork, enzyme
India	Bombay *Nashik* *Vashi*, New Bombay	Spices Onions, potatoes Spices
Indonesia	Pasar Jumat (1988) Cibitung (1992)	Spices, rice

Iran	Tehran (1991) *Yazd**(1997)	spices Dried fruits, nuts
Israel	Yavne (1986)	Spices, condiments, dry ingredients
Italy	Bergamo* (1996) *Padoa**	Spices Spices
Japan	Shihoro (1973)	Potatoes
Korea, Rep.	Seoul (1986)	Garlic powder, spices and condiments
Mexico	Mexico City (1988) Mexico City (1997)	Spices and dry food ingredients Spices and dry food ingredients
Netherlands	Ede (1981)	Spices, frozen products, poultry, dehydrated vegetables, egg powder, packaging material
Norway	Kjeller (1982)	Spices
Poland	Warsaw (1984) Wlochy* (1991) Lodz (1984)	
Peru	Lima (1996)	Spices, food additives, animal feed
South Africa	Durban (1989) Pretoria (1968) Kempton Park (1982) Cape Town (1986)	Spices Shelf-stable food Spices Fruits, spices
Thailand	Patumthani (1989) *Leam Chabang* (1998)	Onions, Fermented pork sausages, enzymes, spices Service irradiator for food and non-food products
United Kingdom	Swindon (1991)	Spices
USA	Rockaway, NJ (1984) Whippany, NJ (1984) Tustin, CA (1984) Ames, IA* (1993) Mulberry, FL (1992) Schaumberg, IL Columbus, OH Morton Grove, IL Haw River, NC Salem, NJ *Hilo, HI* (1998)Spices	Spices Spices Spices Spices, poultry Fruits, vegetables, poultry, spices Spices Spices Spices, fruits Spices Spices Tropical fruits
Yugoslavia	Belgrade (1986)	Spices

Facilities with locations in *italic* are under construction or planned;

Countries in *italic* are irradiating food for commercial use

(All facilities use Co-60 as radiation source except those indicated by * which are electron beam facilities)

Although several countries have already used irradiation to process some food products during the 1980's, it was not until the early 1990's when significant awareness of the use of this technology was realized by governments, food industry and the media, especially in the USA, following the opening and commercial processing of food by Vindicator, Inc., Mulberry,

Florida in early 1992. The first batch of strawberries irradiated by the first commercial food irradiator in the USA attracted wide publicity. The retailed sale of irradiated strawberries and other produce which followed, also attracted wide attention both within the USA and elsewhere (Marcotte, 1992; Pszczola, 1992). A retail store in Chicago area reported overwhelm successes in selling irradiated produce. Irradiate strawberries outsold the non-irradiated berries by a ratio up to 20:1. It also reported a significant saving by reducing spoilage losses (about 10% for non-irradiated strawberries) to about 2 % for irradiated berries. The reduction of spoilage not only provided this store with additional profit margin but enable it to compete with larger retailers by offering better quality products at the same price charged by other stores for lower quality products (Corrigan, 1993). The success of sale of irradiated produce has led to sales of irradiated chicken starting from 1993 and tropical fruits from Hawaii starting from 1995 which were also successful (Pszczola, 1993; Moy, 1996).

Trade developments

a. Replacing fumigation of food

Fumigation of food and food ingredients with various chemicals, such as ethylene dibromide (EDB), methyl bromide (MB), and ethylene oxide (ETO), either has been prohibited or is being increasingly restricted in most advanced countries for health, environmental, or occupational safety reasons. EDB was banned by the U.S. Environmental Protection Agency since 1984 (EPA, 1983). The importing from other countries of any food treated with EDB for sale in the USA is also prohibited. Most countries have followed the USA in banning the use of EDB for fumigating food and food ingredients for insect disinfestation purposes.

It appears that MB, the most widely used fumigant for food and agricultural products against pests such as insects and nematodes, will likely suffer the same fate as EDB. MB has been listed under the Montreal Protocol (an international treaty for the regulation of ozone depleting substances worldwide and under the auspices of the United Nations Environmental Programme) as one of the substances which causes depletion of ozone layer. The original phase-out schedule of MB was set for the year 2000. However, the last meeting of the Parties to the Montreal Protocol held in Montreal, Canada in September 1997 had revised the phase-out schedule of MB according to the following:

Advanced countries:	25% reduction by the year 1999
	50% reduction by the year 2001 70% reduction by the year 2003 Phase-out by the year 2005 (with exemption for critical uses)
Developing countries:	20% reduction by the year 2005
	Phase-out by the year 2015

The use of MB for quarantine purposes and for preshipment fumigation was exempted from the phase-out schedule under the Montreal protocol.

The global phase-out of MB is complicated by the fact that lhe USA has a Clean Air Act which requires that any chemical substance which has an ozone depleting potential (ODP) of 0.2 and above must be deregistered for use. MB is reported to have ODP of 0.7. The U.S. Environmental Protection Agency has published the final rule for MB on 30 November 1993

which will terminate production and consumption of MB on 31 December 2000 (EPA, 1993). There is no exemption for the ban of MB in this regulation. Although there is a movement in the US Congress to delay the phase-out schedule of MB to be in conformity with that of the Montreal Protocol, it is clear that MB is on the way out and that it will not be available for controlling pests in food and agricultural products in the near future.

Ethylene oxide (ETO), another widely used fumigant for decontaminating insects and microorganisms in dry food ingredients, particularly spices and dried vegetable seasonings, was banned by the European Union starting from 1 January 1991 (Dickman, 1991). The U.S. Environmental Protection Agency has issued a final rule which prohibited the use of ETO for fumigating processed spices on 22 March 1996 (EPA, 1996). However, EPA has not enforced the rule pending further review of data submitted by the spice industry. Again, it is clear that ETO is also on the way out in the USA as well.

Irradiation has been demonstrated as an effective method to replace the fumigants mentioned above. Low-dose irradiation between 0.2 and 0.7 kGy can control effectively insect infestation of grain and other stored products (IAEA, 1991a). Unlike fumigation, irradiation does not leave any residues in or on the products. To prevent re-infestation, grain and stored products must be properly packaged in insect proof containers.

Low-dose irradiation is being considered as an alternative to EDB and MB fumigation of fresh agricultural products to overcome quarantine barriers in trade. A minimum dose of 0.15 kGy is effective as a quarantine treatment of fresh fruits and vegetables against fruit fly of tephritidae family, and a minimum dose of 0.3 kGy effective against other insect species (IAEA, 1991b). Unlike other competing techniques, irradiation is a broad spectrum quarantine treatment, not specific to insect species or host commodities. Its application as a quarantine treatment of fresh horticultural produce is endorsed by regional plant protection organizations operate within the framework of the International Plant Protection Organization, i.e. North American Plant Protection Organization (NAPPO), European and Mediterranean Plant Protection Organization (EPPO), Asian and the Pacific Plant Protection Commission (APPPC), etc. The USDA has issued a Notice of Policy on 15 May 1996 which permits irradiation as a quarantine treatment of fresh fruits and vegetables against fruit flies regardless of host commodities (USDA, 1996).

The use of irradiation to replace ETO to ensure hygienic quality of spices and vegetable seasonings has increased significantly following the ban of ETO by the EU in 1991. In term of volume, the production of irradiated spices and dried vegetable seasonings worldwide has increased from about 10,000 tonnes in 1990 to over 60,000 tonnes in 1996 as it offers a broad spectrum treatment for sanitizing spices and vegetable seasonings, often at a more competitive cost than other competing processes. Irradiation is therefore being used as a routine process for sanitizing spices and other dried food ingredients in several countries.

b. Satisfying hygienic standard in food trade

With the increasing recognition of food-borne outbreaks from pathogenic microorganisms and parasites, irradiation is being considered as a method to ensure hygienic quality of more solid food of animal origin, in particular raw poultry, red meat and seafood. These products are often contaminated by bacteria such as *Salmonella, Campylobacter, E. coli 0157:H7, Listeria monocytogenes, Vibrio* spp., etc., which can cause health hazards and even deaths. Thus, consumption of food of animal origin in the raw form represents a high risk to health.

Relatively low dose irradiation can significantly reduce the risk from these foodborne pathogens without affecting the physical characteristics and sensory quality of these food (Loaharanu, 1996).

Health authorities in many countries have introduced stricter hygienic standards in food trade. Such standards often require zero tolerance of pathogens such as *Salmonella* and *Vibrio cholerae* in imported food products. Some countries, notably the USA, have already introduced zero tolerance for *L. monocytogenes* in ready-to-eat food in trade. In September 1994, the USDA proposed a legislative bill to the Congress on 'Pathogen Reduction Act' which will require inspection for pathogenic microorganisms in meat and poultry, recall of meat products contaminated by such organisms and penalties for selling such contaminated products. In addition, the USDA/FSIS has reclassified *E. coli* 0157:H7 as an adulterant although it will limit its current reclassification of this pathogen only to raw ground beef. Such a USDA reclassification could serve as an "important legal point" for the same pathogen in other products as well as other similar pathogens in raw meat, poultry and seafood. The recent massive recall of 10,000 metric tonnes of frozen hamburgers contaminated by *E. coli* 0157:H7 in the USA had resulted in increasing demand for the use of irradiation to ensure hygienic quality of such food. The US-FDA is under an active consideration to approve the use of irradiation for this purpose in the near future.

c. GATT Agreement on the application of sanitary and phytosanitary measures

The positive conclusion of the Uruguay Round of GATT Multilateral Trade Negotiations in December 1993, especially the adoption of the Agreement on Sanitary and Phytosanitary Measures - entered into force when the World Trade Organization (WTO) was established in 1995, will add further incentive to international trade in irradiated food. Under the Agreement, government which is a member of the WTO could be required to furnish justification for food import restrictions based on national regulations that are stricter than standards, guidelines and recommendations of the following organizations:

- Codex Alimentarius Commission (food safety and human health)
- International Plant Protection Convention (plant protection and quarantine)
- International Office of Epizootic (animal health).

An exception is made if the importing county can provide scientific proof that the importation of such food could endanger health of their citizens, animals or plants.

The safety and effectiveness of irradiation as a method of food processing/preservation have been recognized by the Codex Alimentarius Commission when it adopted a Codex General Standard for Irradiated Foods in 1983. The Standard and its associated Code of Practice were recommended to all member governments of the Codex for acceptance in 1984. Regional plant protection organizations operate within the framework of the International Plant Protection Convention including NAPPO, EPPO, APPPC, etc. have endorsed irradiation as an effective quarantine treatment of fresh agricultural products since 1991. With the increasing stricter hygienic and phytosanitary standards required in international food trade and the prohibition and restriction of chemical preservatives and fumigants in and on food, irradiation is likely to play a more prominent role in food trade in the near future.

Conclusions

After decades of research, development and public debate, food irradiation is moving to centre stage along with other technologies in its quest to feed the increasing world population and to overcome barriers in food trade. At the top of the list of application of this technology are its use to ensure hygienic quality of more solid food, especially those of animal origin and spices and other dried food ingredients; as a quarantine treatment of fresh agricultural produce; as a method to protect grain and other stored products from insect infestation; and as an innovative method, in combination with other food technologies, to improve safety and quality of food with less energy requirements. The Agreement on the Application of Sanitary and Phytosanitary Measures, adopted during the Uruguay Round of GATT Multilateral Trade Negotiations, will add further incentive to international trade in irradiated food.

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