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# *Harmonization of regulations on food irradiation in Asia and the Pacific*

*Proceedings of a Seminar jointly organized by the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and the Western Pacific Regional Office, World Health Organization and held in Kuala Lumpur, Malaysia, 20–24 January 1992*

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# FOREWORD

An adequate supply of safe, wholesome and nutritious food is often hampered by the problems of food safety and post-harvest losses. Various methods of food preservation can reduce losses due to spoilage and deterioration, as well as the control of pathogens and parasites that cause foodborne diseases. Based on decades of research and unprecedented number of studies, food irradiation is now widely accepted by many governments and United Nations agencies as safe and effective in reducing foodborne pathogens and parasites and in prolonging shelf-life of fresh produce. Food irradiation can contribute significantly to food safety and to facilitation of trade, but legislation permitting its use is essential for the commercialization of the process.

Following the adoption of the Codex General Standard for Irradiated Foods and its associated Code of Practice by the Codex Alimentarius Commission in 1983, nearly forty countries have approved food irradiation for the treatment of one or more types of food, including some countries in the Asia and Pacific region. Food irradiation was recently reviewed and endorsed by 57 countries attending the International Conference on the Acceptance, Control of and Trade in Irradiated Foods, jointly convened by FAO, IAEA, WHO and ITC-UNCTAD/GATT in Geneva in December 1988. Within the foreseeable future, there may be significant international trade in irradiated food products in the Asia and Pacific Region and the world.

Given the unique potential of food irradiation technology in overcoming certain food safety problems, and its technological and commercial advantages in controlling insect pests and increasing shelf-life of fresh produce, it would seem desirable for countries in the Asia and Pacific to introduce appropriate regulations in preparation for an increase in demand for irradiated food products. Moreover, it would be desirable to take steps to ensure that the introduction of such regulatory control be done in a consistent manner leading to uniform regulations which reflect internationally accepted control measures.

In 1989, the Food Preservation Section of the Joint FAO/IAEA Division on Nuclear Techniques in Food and Agriculture, which is responsible for the practical application of irradiation technology in agriculture and food processing, approached WHO about the possibility of convening a joint seminar on food irradiation legislation. Also, at the WHO Regional Seminar on Food Safety Legislation which was held in Kuala Lumpur, Malaysia, from 27 to 30 August 1990, participants recognized the importance of food irradiation legislation but because of its complexity, such legislation could not be discussed in detail. Therefore, it was considered timely and useful to the countries in Asia and the Pacific to convene the regional seminar to assess the current situation concerning the enactment and enforcement of regulations on food irradiation and discuss the strategy for the introduction and implementation of regulations base on the principles of the Codex General Standard for Irradiated Foods and the recommendations of other international meetings related to the subject.

The seminar was convened by WHO Western Pacific Regional Centre for the Promotion of Environmental Planning and Applied Studies (PEPAS) and the Joint FAO/IAEA Division, with gracious support from the Malaysian Government, at the Federal Hotel, Kuala Lumpur, Malaysia from 20 to 24 January 1992. It was attended by 54 participants and observers from 22 countries, including 17 from the Asia and Pacific region.

Twenty-two invited presentations and seven contributed papers described the current status of food irradiation in the region and the world, with particular emphasis on regulatory control requirements, and the acceptance of irradiation by consumers and its adoption by industry.

Eight technical sessions covering various aspects of food irradiation and harmonization of regulations (e.g. food irradiation - its contribution to food safety, trends in commercial application, technical basis of regulatory control of the irradiation facility and the process as well as irradiated food in trade, current status of application and regulatory control, etc.) were included in the seminar programme. A summary of the seminar, including the conclusions made by the participants, is included in the proceedings.

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# SUMMARY AND CONCLUSIONS

## SUMMARY

**Objectives of the Seminar:**

The World Health Organization (WHO) Western Pacific Regional Centre for the Promotion of Environmental Planning and Applied Studies (PEPAS), jointly with the International Atomic Energy Agency (IAEA) and the Food and Agriculture Organization (FAO) of the United Nations, convened the WHO/IAEA/FAO Seminar on Harmonization of Regulations on Food Irradiation in Asia and the Pacific, held in Kuala Lumpur from 20 to 24 January 1992 in order:

(a) to review the current situation in Asia and the Pacific concerning the enactment and enforcement of regulations on food irradiation;

(b) to discuss technical issues facing national regulatory control authorities (including those involved in food regulation, control and safety, and plant protection and quarantine) in introducing and implementing regulations based on the principles of the Codex General Standard on Irradiated Foods and the recommendations of other international meetings related to the subject;

(c) to exchange views on the development and harmonization of national regulations and the development of effective control procedures for ensuring that good irradiation practices are followed and that irradiated products are of acceptable quality; and

(d) to familiarize the participants with issues relating to the promotion of food safety and to the facilitation of the movement of irradiated foods in international and intra-regional trade.

**Summary of proceeding and conclusions:**

The Seminar was attended by 54 participants and observers from 22 countries, including 17 from the Asia and Pacific region. In addition, six representatives from national, intergovernmental and non-government organizations also attended.

Twenty-two invited presentations and seven contributed papers described the current status of food irradiation in the region and the world, with particular emphasis on regulatory control requirements, and the acceptance of irradiation by consumers and its adoption by industry.

The Seminar provided an opportunity to exchange considerable information on food irradiation and its potential capacity to facilitate trade in food and to help control two of the most serious problems connected with food supplies - i.e. the extensive loss of food through deterioration, and the illness and death that result from food contaminated with pathogens and parasites. In addition, irradiation treatment is an alternative to chemicals in controlling foodborne diseases and for quarantine treatment.

The participants concluded that increased food trade is of vital importance to further economic development of the region and that food irradiation can improve the safety, quality and quantity of food available, both domestically and for international trade. Moreover, they agreed that application of this technology should be in accordance with recognized international standards (i.e. Codex Alimentarius), good manufacturing practices, and other food control tools like the Hazard Analysis Critical Control Point (HACCP) concept for total quality management. They agreed that national authorities should work toward uniform regulations for food irradiation using the available intergovernmental coordination mechanisms such as the Codex Alimentarius Commission and the International Consultative Group on Food Irradiation. The participants stressed that clear, open, factual communication with the public on the benefits of the process and its products is a vital factor in successful commercialization of food irradiation.

A regional strategy to achieve harmonization of regulations should be based on:

(a) national policies, regulations and directives in accordance with international standards, codes and guidelines;

(b) effective enforcement of control measures by competent authorities, including fully informed regulatory officials on the technical basis of the safety, benefits and limitations of food irradiation;

(c) factual consumer information programmes by governments, industry and consumer associations; and

(d) the health needs and competitive advantage of the Asia and Pacific region to produce spices, dried herbs, seafood, fruits and vegetables.

## CONCLUSIONS

The participants recognized that:

(1) International trade in food involving the Asia and Pacific region has important public health implications and, moreover, can contribute significantly to the economic development of the region. Continued effort should be made to facilitate (e.g. reduce tariff and non-tariff barriers) and augment the size and scope of this trade.

(2) All methods of conserving the food supply and ensuring its wholesomeness, safety and quality require regulatory control by competent authorities.

(3) Irradiation is an effective food technology which can reduce pathogen contamination in foods, reduce post-harvest losses, enhance the variety and quality of foods for consumers, and serve as an effective quarantine treatment for certain foods.

(4) Clear, open, factual communication with the public on the process and its products is necessary to enhance consumer acceptance and understanding of food irradiation which may assist the adequate supply of safe and nutritious food. Knowledge that a harmonized regulatory framework is being established will also contribute to consumer confidence, acceptance and commercialization of this technology.

A regional strategy to achieve harmonization of regulations within Asia and the Pacific should be based on the following:

(5) Harmonization of national regulations on food irradiation would facilitate food trade and protect consumer health in the Asia and Pacific region as well as internationally. National authorities in the region should work toward uniform regulations for food irradiation, possibly through the respective Codex Coordinating Committees and meetings organized by the International Consultative Group on Food Irradiation (ICGFI).

(6) National regulatory control of food irradiation should be in accordance with the principles of the Codex General Standard for Irradiated Foods, the Codex Code of Practice for the Operation of Radiation Facilities Used for the Treatment of Foods and the Codex Standard for the Labelling of Pre-packaged Foods. Food irradiation should not be used as a substitute for Good Manufacturing Practices (GMPs).

(7) Application of irradiation treatment of foods by processors should be in accordance with the Good Irradiation Practices (GIPs) elaborated by ICGFI and the Hazard Analysis Critical Control Point (HACCP) concept for total quality management, including food safety.

(8) Managers, operators and inspectors of food irradiation facilities and food control officials should be trained in irradiation treatment of foods by attending and meeting the requirements of the process control schools organized by ICGFI, or similar recognized training programmes established by individual governments.

(9) National authorities should ensure that the registration of food irradiation facilities satisfy the criteria established by ICGFI for inclusion in its international register.

(10) An international certification mechanism for exported foods treated by irradition would enhance the confidence of, and assist in acceptance by, importing countries. This mechanism should be supported by periodic evaluation and inspection by national authorities. Exporting countries should allow the same products to be marketed domestically.

(11) Development of methods for detection of irradiated foods and quantification of the absorbed dose should continue with the objective of supplementing regulatory control procedures, particularly after treated products have left the irradiation facility.

(12) Collaboration among the research centres with irradiation capability in the Asia and the Pacific region should be fostered by international organizations, interested governments and industry, with special emphasis on training, detection technology and applications which benefit public health and trade.

(13) A regional strategy on harmonization of regulations based on the above could be used to facilitate progress on harmonization through inter-regional discussions and dissemination of information.

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# OPENING ADDRESSES

# OPENING ADDRESS

**L.R. Verstuyft**
WHO Representative for Brunei Darussalam, Malaysia and Singapore

On behalf of Dr S.T. Han, Director of WHO's Regional Office for the Western Pacific, I have pleasure in welcoming you to this seminar on harmonizing the regulations on food irradiation in Asia and the Pacific.

The World Health Organization strongly promotes the development of national food safety programmes so that governments can ensure an adequate supply of safe, nutritious and acceptable food. To this end, WHO has facilitated a broad range of activities at a national, regional and interregional level based on sound scientific knowledge. WHO brings together the world's most qualified experts to review and advise on specific technical aspects of keeping food safe. Food irradiation is a technology that WHO has examined in detail because of its potential for extending the shelf life of fresh produce, reducing the degree of post-harvest losses due to insects and other pests, and destroying many foodborne pathogens and parasites, hence, making the food supply safer.

In the past, WHO has collaborated with the International Atomic Energy Agency and the Food and Agriculture Organization to ensure the desirability and safety of the food irradiation process. The available information has been reviewed by Expert Committees jointly organized by WHO, IAEA and FAO in 1961, 1964, 1969, 1976 and 1980. The Joint Expert Committee on Food Irradiation concluded in 1980 that the irradiation of any food commodity with a dose of up to 10 kiloGray caused no toxicological hazard and no special nutritional or microbiological problems. The microbiological quality of irradiated food was further reviewed at a meeting of experts in Copenhagen in December 1982, which concluded that food irradiation was an important addition to the methods of food processing for preservation and control of foodborne pathogens and did not present any additional hazards to health.

Following the findings of these expert meetings, the Codex Alimentarius Commission, in 1983, adopted the Codex General Standard for Irradiated Foods and the Recommended International Code of Practice for the Operation of Radiation Facilities for the Treatment of Foods. This Codex General Standard provides a model by which governments can implement food irradiation as a safe food processing technology.

In 1984, an International Consultative Group on Food Irradiation was established to evaluate global developments, provide a focal point for advice and furnish information on food irradiation. The Group currently has 28 Member Countries and meets periodically under the aegis of WHO, FAO and IAEA.

Food irradiation was most recently reviewed and endorsed by the International Conference on the Acceptance, Control and Trade in Irradiated Food, jointly convened by WHO, FAO, IAEA and International Trade Commission in Geneva in December 1988.

Still, the attitudes of governments towards food irradiation are quite varied. They range from those which have not yet considered the process, through those that have a moratorium on it for the moment, to those that are actively applying the technology. The forces which play a role in determining government attitudes are, of course, as diverse as the attitudes themselves.

It is, therefore, important to hold seminars such as this to promote international discussions on food irradiation to enhance awareness of the benefits of the process. In this way, we can also encourage the active participation of all interested parties, dispel concern regarding the safety of the technology and encourage governments to develop adequate regulatory controls.

Already, 37 countries have provisions in their regulations allowing the use of food irradiation on specific commodities. However, these provisions vary from country to country.

Regulations in the United States of America now permit the irradiation of papayas to comply with quarantine regulations and the irradiation of poultry, spices and pork for food safety reasons. Food irradiation is also used in the United Kingdom and other countries in Europe, and a directive is being developed by the European Community to permit the free circulation of irradiated food. All this indicates growing interest and confidence in this technology.

Within the Western Pacific Region, several countries including China, Japan, the Philippines, the Republic of Korea and Viet Nam have already approved food irradiation for the treatment of one or more food items. Irradiation of selected foods is also permitted in Western Pacific areas under the jurisdiction of France, the United Kingdom and the United States. Thus, there is already significant pressure for increased trade in irradiated foods in the Region and it would seem desirable for Member States throughout Asia to introduce appropriate regulations in preparation for an increase in demand for irradiated food products. Furthermore, it is highly desirable that the introduction of such regulatory control of food irradiation should be done in a consistent manner. This would help to bring in uniform regulations which reflect internationally acceptable standards. This seminar therefore presents a timely opportunity to facilitate the necessary discussions between governments and other interested parties.

In conclusion, I would like to express our deep appreciation to the Government of Malaysia for its generous financial support for this seminar.

I encourage all of you to participate actively in the discussions so that you can find out what role your governments can play in establishing regulations on irradiated foods. Such regulations would enhance international trade in safe, nutritious and acceptable food.

# OPENING ADDRESS

**P. Loaharanu**
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture,
International Atomic Energy Agency, Vienna

It is an honour for me to address you on behalf of the Directors General of the International Atomic Energy Agency (IAEA) and of the Food and Agriculture Organization of the United Nations (FAO) on the occasion of the opening of this Seminar. On behalf of the Directors General, I would like to thank the WHO Office for Western Pacific for co-sponsoring this important Seminar with FAO and IAEA. I am grateful to the Malaysian Government, through its Nuclear Energy Unit, to provide financial assistance for organizing this Seminar. I also would like to thank you, Your Excellency, the Minister, Datuk Ghazali and Dr Verstuyft for being here on this occasion to underline the interest of the Malaysian Government and WHO Regional Office in and strong support of this regional Seminar. I would like to inform you that the Seminar represents not only the first cooperation between WHO Regional Office and FAO/IAEA but is the first one in which WHO plays a prominent role in the field of food irradiation. I would also like to thank Dr Guo and his colleagues at PEPAS for their most cordial and effective cooperation in the preparation of this Seminar.

As mentioned by you, Dr Verstuyft, this Seminar is attended by scientists and officials from 15 countries in Asia and the Pacific as well as from countries outside the region. This Seminar follows two earlier successful ones convened by FAO/IAEA for the Asian and Pacific Region, the first in Tokyo in 1981 and the second in Shanghai in 1986.

Ladies and Gentlemen: According to FAO, the Region of Asia and the Pacific Region accounts for over 50% of the world's population, more than 70% of the world's farming households, about 75% of the world's malnourished people, but only 27% of the world's arable land. With a world population of already over 5 billion at the beginning of 1990, there will be over one billion more people to feed at the end of this decade. Food availability and better nutrition for the world's population, especially of the Asian and Pacific Region, are among the most important challenges facing us today. Policy makers need to address issues which are constraints to food production and economic development and which contribute to the persistent problem of hunger and malnutrition.

While there are several methods of food processing and preservation which have contributed positively to food availability, nutrition and trade, we cannot afford to reject other safe and effective technologies which could strengthen food security, health and trade in countries of the third world. One such technology is food irradiation, which offers much promise as a method for reducing post-harvest food losses, ensuring hygienic quality of food and facilitating wider food trade. The safety and effectiveness of this technology have been evaluated by many national and international committees, all of which recommended its application. Food irradiation has been endorsed by designated experts from 57 governments, who attended the International Conference on the Acceptance, Control of and Trade in Irradiated Food, convened by FAO, IAEA, WHO and ITC-UNCTAD/GATT, Geneva, Switzerland, December 1988. It has also been recently endorsed by the Codex Committee on Food Hygiene of the Codex Alimentarius Commission.

The increasing interest in recent years shown by governments and industry in the practical application of food irradiation technology has resulted in wider acceptance of this process and the promulgation of appropriate regulations by many public health authorities. Thirty seven countries have approved its use collectively for 40 different food items or groups of food for consumption. Among these countries, 24 are using the technology for semi-commercial or commercial scale processing of food.

Trade in irradiated foods, while small in quantities, has increased significantly in the past decade. The potential of food irradiation to overcome problems in food losses, foodborne diseases and food trade, is virtually unlimited. The countries in Asia and the Pacific could benefit significantly from the use of this technology in view of the rich agricultural resources in the region. Food irradiation is already beginning to have an impact in the spice trade, most of which originates from this region. Some 17 countries worldwide are using the technology rather than chemicals to improve the hygienic quality of spices.

Lack of harmonization of national regulations on food irradiation remains an important barrier to international trade in irradiated food. In this context, a step was made in the right direction by the European Communities as the Commission for the European Communities recently proposed Directives for the Control of Irradiated Foodstuffs. Hopefully the Directives will be finalized under the EC procedures before the end of 1992. Many political debates have ensued and the outcome of the discussions on the Directives is far from certain.

On the other hand, positive steps were taken by the national plant protection authorities in Canada, Mexico and the USA through the North American Plant Protection Organization (NAPPO) which agreed, in October 1989, to accept irradiation as a quarantine treatment of fresh, agricultural produce.

Given the potential of food irradiation technology in overcoming certain food safety problems, such as parasites and pathogens, and also its technological and commercial advantages in controlling insect pests and extending shelf-life of fresh produce, it was thought timely to convene this Seminar in order to promote steps to be taken to ensure that regulatory control of food irradiation is done in a consistent manner leading to uniform regulations which would facilitate trade.

Again, on behalf of the Directors General of FAO and IAEA, I wish to extend my gratitude to my colleagues from WHO, invited speakers and all participants and observers for their interest and participation in this important Seminar.

## OPENING ADDRESS

**The Honourable Mr. Law Hieng Ding**
Minister of Science, Technology and the Environment, Malaysia

First of all let me extend to you all a warm Malaysian welcome - "Selamat datang to Malaysia". I would also like to thank WHO, IAEA and FAO for providing me with the opportunity to address this morning's Seminar on the Harmonization of Regulations on Food Irradiation in Asia and the Pacific.

As societies rapidly develop, the quality and safety of food becomes an increasingly important issue. The quantity and quality of food reaching the public is reduced by post-harvest losses as a result of insects and other pests, chemical and microbial deterioration and by the presence of microbial pathogens. In fact, foodborne disease is considered to be a significant cause of diarrhoeal diseases, often leading to mortality in children. For example, Hepatitis A, associated with the consumption of shellfish, was the recent cause of illness in 292,000 people in just one outbreak in Asia and, in recent times, the world has also seen cholera epidemics in South America, Africa and some countries of Asia that had worldwide effects on the international trade in foods. It is, therefore, important for both developing and developed societies to harness scientific and technological advances in an effort to assure the quality and safety of food.

The irradiation of food for the purposes of disinfestation and preservation is a unique example of applying science and modern technology to reduce food losses and has the potential to be, perhaps, the most significant advance in food preservation since the introduction of pasteurisation, refrigeration and canning. However, for food irradiation to reach its full potential benefit, it must gain acceptance from all sectors - the governments, the food industry and consumers. The acceptance of the process by governments and industry varies widely across the region and is dependent upon the resolution of a number of economic and technical issues facing both the food industry and national regulatory control authorities as well as the attitude of the public to the irradiation of food. Consumer acceptance can only be built on solid scientific evidence of the safety and benefits of the process, by ensuring strict adherence to regulatory control and by dissemination of accurate information on the process. As of today, consumer understanding of the technology is still limited and the level of consumer acceptance is still unknown.

Since food irradiation is commonly confused with contamination by radioactive materials, it is the responsibility of international organisations, government, industry and consumer associations to educate the consumer and reduce public confusion. In Malaysia, a number of approaches and organisations are involved in establishing a better understanding of food irradiation as a preservation process. To achieve a high level of public understanding, these educational activities should utilise an integrated approach to ensure access to up-to-date and accurate information from organisations such as the World Health Organization, the International Atomic Energy Agency and the Food and Agricultural Organisation as well as from the Nuclear Energy Unit and the Food Quality Control Unit of the Malaysian Government in association with clear and accurate messages from industry and national and international consumer associations. The role of the food industry in particular must be strengthened. Currently, much of industry's efforts is aimed at product promotion. This needs to be redirected so that industry also plays an important role in disseminating information on quality and safety aspects of food. Consumer associations must also be encouraged to ensure factual messages on food quality and safety and not clouded by emotive terminology. After all, it is in the interest of all that the advantages and limitations of the food irradiation process should be publicised. As the Honourable Prime Minister, Dato Seri Dr Mahathir bin Mohamad said at the opening of the First Asian Conference on Food Safety - "Food safety ..... is of personal interest to all of us, to our families and to our nations.". Seminars such as this, will facilitate the educational process by ensuring information exchange on the irradiation process and products of food irradiation.

I believe it is every government's aim to establish a framework in which industry can flourish and the consumer has access to both a greater diversity of foods and safe food. Legislation and regulations can control the quality and safety of food and control the development of irradiation facilities and processes. Government's role is to ensure that industry is aware of its responsibilities and that it adheres to the regulations either through voluntary compliance or through government enforcement. Once governments establish proper regulatory control of food irradiation, in a harmonized approach, the international trade in irradiated foods will see a tremendous expansion. Of particular importance to Malaysia and this region is the potential for expanded trade of fresh tropical fruits and vegetables as well as trade in spices. To facilitate the development of complementary national legislation, standards and regulations for all countries of the region, the Codex Alimentarius Commission has developed standards for irradiated foods and a Code of Practice for the operation of irradiation facilities used for the processing of food. Also, the International Consultative Group on Food Irradiation has produced a guideline for ".. Preparing Regulations for the Control of Food Irradiation Facilities". Governments, thus, have a good base from which they can build a legislative framework and regulatory control that would enhance international trade in irradiated food. I urge all those involved in the regulatory control of irradiated food to consider the importance of utilising such guidelines and to carefully consider the information presented in the seminar documents.

In conclusion, it is important to both the economy of the countries of the region and the health of the people that all efforts are undertaken and all opportunities are grasped to apply technological advances such as the irradiation process to enhance the quality, safety and diversity of food available to us all. With these remarks, I wish this seminar every success in its deliberations and I have much pleasure in declaring the seminar open.

# INVITED PAPERS

## FOOD IRRADIATION — ITS CONTRIBUTIONS TO FOOD SAFETY

(Session I)

**Chairman**

**P. GUO**
WHO Regional Centre for the Promotion of
Environmental Planning and Applied Studies (PEPAS)

# FOOD IRRADIATION TECHNOLOGY — A GENERAL OVERVIEW OF ITS BENEFITS AND LIMITATIONS

N. TAPE
Ottawa, Canada

## Abstract

Food production and marketing are being transformed by urbanization, technological change, consumer demands, regulatory requirements and increasing interdependence among countries and regions. In every country, the agri-food sector is a large, vital component of economic development, both in national and international terms. Within this changing environment, the commercialization of new agri-food technologies is becoming more difficult and challenging. Food irradiation appears to be facing similar objections, to those experienced by "pasteurization" many decades ago. However, a general consensus has been achieved among governments that irradiation, from gamma or electron sources, can contribute positively to food security, safety and global food trade. Intergovernmental collaboration has lead to standards, codes of practice, guidelines, training and good sources of information on food irradiation. Wise application of these resources in an open manner will lead to the successful introduction of new food irradiation facilities and to global trade in irradiated foods. The addition of irradiation preservation to existing food technologies will broaden our overall capability to maintain agricultural and fisheries produce in a safe condition and, as well, to market quality products.

It may appear elementary to pose the question "Why process food?". As food technologists, marketers or regulators, the response is obvious, i.e.:

- to prolong storage life
- to facilitate transportation
- to enhance food safety
- to maintain nutritional value
- to control pests

However, the demographic and social factors behind these technical justifications for processing are (a) the geographical location of large markets and (b) consumer demands for a safe, wholesome, convenient, reasonably priced food supply. In most countries, the majority of people now live in cities which are distant from farm production and fish harvesting and, moreover, they have limited household storage capacity for food. As a result, technologies and transportation systems have been developed to provide distant markets (hundreds to thousands of kilometers away) with fresh and processed foods. As domestic and export food trade expands to serve these distance markets, there is continual need to enhance preservation technologies, particularly to control foodborne diseases, reduce waste and protect plant and animal health.

**Food trade**

The agri-food industry (agriculture and fisheries) is the largest industrial sector in every country. Even in small countries like Canada (26 million population) the food industry is a vital economic component. Canada's farmers have cash receipts exceeding $21 billion, with over half of the sales to the export market. The value of shipments from food and beverage processing plants exceeds $44 billion, with approximately 25% going to the export market. The food sector's contribution to national employment is also very significant - e.g. nearly one in four jobs in Canada are related to food, including employment in basic production, processing, transport, marketing, retail sales and restaurants. The scope and nature of statistics in other countries would be similar to those in Canada, i.e. demonstrating the food sector's significant impact on the national economy.

World food trade figures are also very large and growing. The annual value of world trade in food for human consumption is in the order of US$200 billion, representing about 460 million metric tonnes of food stuffs. Global food trade is expanding every year, thanks to rapidly growing consumer demand, developments in food science and technology and in transport, and the need of countries to earn foreign exchange. The priority given to trade in food in the current "Uraguay Round" of the GATT demonstrates the need for harmonization of price supports, subsidies and standards. In a very striking manner, "food" illustrates the interdependence of the world economy.

**Major preservation technologies**

Major technologies used to preserve food products are dehydration, heat treatment (e.g. canning, pasteurization), freezing, chemical treatments (salt, sugar, additives), fermentation and fumigation. In a global context, dehydration and heat treatment are the dominant technologies.

While significant enhancements have been made to all of these technologies through the past decades, the discovery of "pasteurization" by Louis Pasteur and "canning" by Nicholas Appert remain as the significant milestones in food technology. It is interesting to note that these discoveries were made well over 150 years ago and that no discovery of equivalent significance, except food irradiation, has emerged since then.

**Irradiation preservation**

The first referenced use of irradiation to improve the condition of foodstuffs and their general keeping quality was made in the United Kingdom in the year 1905 - i.e. a patent for the treatment of foods, especially of cereals and their products, with radiation from radium or other radioactive substances. Later, in 1921, U.S. government scientists proposed the use of X-rays for inactivating *trichinae* in pork.

Following these early discoveries and proposed used, food irradiation experienced several stages of development. Many countries established extensive research and development programmes in the 1950s and 1960s. Data from these research programmes were evaluated by national and international groups of experts. This lead to the conclusion by the Joint Expert Committee on Food Irradiation that the irradiation of foods is a useful process with significant benefits for both consumers and industry, and that the irradiation of any commodity up to an overall dose of 10 kGy presented no toxicological hazard. This lead, in the 1980s, to international standards and regulations by the Codex Alimentarius Commission and subsequently by many national governments. Commercialization also increased in the 1980s, leading, hopefully, to trade in irradiated food in the 1990s.

At the present time, approximately 700,000 metric tonnes of agricultural and fisheries produce, food or food ingredients are irradiated annually. Currently, 24 countries are using food irradiation to reduce food losses and ensure the hygienic quality of a variety of food items, e.g. potatoes, onions, bananas, mango, grain, poultry, shrimp, frogs legs, spices, etc. The largest volume application is the disinfestation of grain at the Port of Odessa using electron accelerators. There are, in total, approximately 30 pilot or industrial irradiators, the majority of which are primarily used to sterilize disposable medical products or other non-food items. One of the more common food applications is the irradiation of spices and herbs. Over 15,000 tonnes of such foodstuffs were irradiated in 17 countries in 1989. Moreover, nearly 40 countries have established regulations for food irradiation and have approved one or more of some 40 different food products.

**Benefits**

The treatment of foods using ionizing radiation has been shown to have the following benefits:

(a) it significantly reduces. the health risks in foods associated with foodborne pathogens;

(b) it enhances the quality of perishable produce by increasing its storage life;

(c) it reduces wastage during storage and transportation of root crops, grain and dried foods;

(d) it provides an alternative to chemicals in quarantine treatment of fruits;

(e) it exerts a stabilizing influence on prices to farmers and consumers; and

(f) it permits access to distance markets with quality products, particularly fresh foods.

Several applications can be accomplished at relatively low dose treatments (up to 1 kGy - e.g. extension of the storage life of root crops by the inhibition of sprouting; improving the keeping properties of some fruits and vegetables by delaying their maturation; prevention of losses due to insects in cereals, flours, and pulses by killing or sexual sterilization; quarantine treatment for fruits by killing or sexual sterilization of insects and the destruction of parasites such as *Trichinella spiralis* in pork.

Medium dosed treatments, requiring 1 to 10 kGy, reduce the risk of food poisoning in a variety of meat and seafood products through the destruction of *Salmonella* and other pathogens. Higher dose treatments of 10 or more kGy are used to obtain 'commercially sterility' with spices, dry vegetables and other food ingredients.

Many people advocate that the irradiation of solid foods, such as meats and seafood, to control foodborne pathogens is a scientific discovery equivalent to that of pasteurization and canning. The capability to pasteurize solid foods without heat is a truly remarkable achievement, one which has considerable potential to improve public health in all countries.

The World Health Organization is interested in this technology because food irradiation has the capacity to help control two of the most serious problems connected with food supplies - i.e.

(a) the extensive loss of food through deterioration (often 40 to 50%); and

(b) the illness and death that result from food contaminated with pathogens and parasites.

In addition, WHO notes that irradiation treatment is an alternative to the use of chemicals in controlling foodborne diseases.

**Limitations**

(i) <u>Comparative advantage</u>

The first consideration is that of comparative advantage. All technologies have specific costs, benefits and limitations. No preservation technology is suitable for across the board application - i.e. we do not use refrigeration to preserve every agricultural and fisheries product. Therefore, each situation must be assessed to determine the treatment (or combination) which yields the least cost, best quality and safest product, etc. In some situations, an existing technology may be so firmly entrenched that the capital costs of establishing irradiation processing may be inappropriate. For example, the existence of a modern controlled atmosphere storage system for potatoes and onions would preclude, or at least delay, the introduction of irradiation processing for these crops. However, wherever new storage facilities are being considered or need to be modernized, irradiation may be the most cost effective technology for a number of products.

(ii) <u>Infrastructure</u>

All technologies require appropriate infrastructures, including technically competent staff, raw and final product storage facilities, food control legislation and regulations, quality assurance laboratories, inspection systems, etc. The introduction of food irradiation requires appropriate national legislation, regulatory control, trained staff, storage and processing facilities, quality assurance, etc. In addition, good manufacturing practices

(GMPs) are as important in irradiation processing as in all other preservation methods.

Each technology, including irradiation, needs specialized training for plant operators and managers, as well as food control personnel. For example, industry and government have joined together in many countries to establish training courses for the certification of operators who manage canning retorts.

(iii) Seasonality

Whenever seasonally produced crops are to be irradiated, consideration must be given to other uses in order to operate the plant on an economical basis. As a result, food irradiation plants are often multi-purpose facilities, capable of treating a variety of foods and possibly non-food products such as medical supplies and packaging material.

(iv) Harmonization of regulations

Although 37 or more countries have national regulations to control food irradiation, there is variation in clearance procedures, process control and labelling. The efforts of the Codex Alimentarius Commission have gone a long way towards achieving harmonization, but continued work remains to be done. In total, some 40 products have been cleared internationally - i.e. one or more in each of the countries with national regulations. Greater uniformity in clearances among governments is required in order to facilitate meaningful trade - for example, international acceptance of irradiation for quarantine treatment of fruits could lead to substantial trade.

(v) Consumers

Since food irradiation is associated with nuclear technology, some consumers (and the media) may confuse irradiated foods to radioactive materials. To the public, the words "radiation", "radioactive" and "irradiated" are very similar. Many regulators interpret this public confusion with public apprehension of irradiation processing. Most consumers are not aware of the benefits of this technology and are frequently "alarmed" by sensational press stories. Consumer education is critical to the success of new food technologies, such as irradiation, or hormone use in beef or milk production, or new ingredients to replace sugar or fat in foods.

(vi) Disposal of source

The disposal of radioactive sources is considered by some to be a limiting aspect of this technology, However, disposal is not a problem when appropriate arrangements are made with a supplier of radioactive sources to maintain source strength at a certain level by the replenishment of the radioactive source. Sources of declining strength are reprocessed by suppliers in order to regenerate the required level of radioactivity for rapid through-put of products. In the case of machine sources of ionizing radiation, such as electron accelerators, the issue of disposal does not arise since there is no radioactive source.

(vii) Technical

Exposure to irradiation may lead to the deterioration of quality in some products. For example, the flavour of milk products may change, or high fat content fish may have an off-flavour, or the texture of some fruits may become soft. Therefore, irradiation at the absorbed dose required to achieve the desired result may lead to unacceptable quality.

**Technical monographs**

Technical monographs on a variety of food irradiation applications are currently being prepared by the International Consultative Group on Food Irradiation (ICGFI) to assist governments to consider national authorization of food irradiation, or to help industry prepare the necessary applications for clearance. The monographs will provide a compilation of data on treatment effects. Two monographs are nearing completion:

(a) Irradiation of poultry meat and its products: a compilation of technical data for its authorization and control.

(b) Irradiation of spices, condiments and dried herbs: a compilation of data for its authorization and control.

When completed, the monographs will be published by the International Atomic Energy Agency (IAEA) under their TECDOC series.

**Requirements for irradiation**

(i) Facility approval

On the assumption that national approval has been obtained for the food(s) to be irradiated, the initial requirement is to obtain a licence from the appropriate national authority, such as an Atomic Energy Control Board, to acquire and operate an irradiator, either a machine source or a wet source storage gamma irradiator. The information must be submitted in a consolidated application according to the appropriate guidelines and in sufficient detail to permit an independent assessment of the hazards and the related precautions taken to protect both operators and members of the public. The application should include the proposed use of the irradiator, the nature and design of the source, irradiator construction and operation, shielding, radiation level to be used, safety systems, operating procedures, training manuals, quality assurance procedures, documentation to be maintained, emergency procedures, source loading, replacement and removal procedures and seismic analysis of the plant location.

(ii) Standards and codes

The Codex Alimentarius Commission has established a worldwide Code of Practice for the operation of irradiation facilities used for the treatment of foods. The Code applies to facilities based on the use of radionuclide sources, X-rays or electrons generated from machine sources. The Code describes good irradiation processing practice as well as product and inventory control. The Codex Alimentarius Commission has also adopted a Codex General Standard for Irradiated Foods. This standard is the basis for many national standards. The operation of irradiation facilities would also have to comply with the national or international regulations regarding the commodity being processed, such as those for meat and poultry products.

A useful reference for regulators and management, those involved in introducing food irradiation, is the ICGFI document "Guidelines for Preparing Regulations for the Control of Food Irradiation Facilities".

(iii) Trained staff

The availability of trained personnel to operate the facility is also essential. Training courses and manuals in irradiation processing are organized in a variety of locations by ICGFI. The curriculum of such training will be described later during another seminar session.

(iv) Information

WHO and IAEA have published a number of general information documents independently but the best source of information on all aspects of food irradiation is ICGFI. It was established by the Directors General of the Food and Agriculture Organization (FAO), WHO and IAEA in 1983 and holds annual meeting usually in Vienna. It's membership is nearing 40 countries (over 50% are developing countries). Member States provide funds or services to support the Group's activities which focus on safety assurance, trade, legislation and standards, economic feasibility, technical training and inventories of basic information.

**Future outlook**

It is difficult to predict the rate of commercialization of food irradiation technology. However, there are several positive indicators which support the prediction of slow, steady progress in commercialization of the process and trade in irradiated foods.

One can point to the successful outcome of the Geneva Conference in December 1988 in which 57 countries endorsed the usefulness of the food irradiation process. Only one country abstained and two countries expressed limited reservations to the consensus document. One should also note the existence of a Draft European Community Directive on Food Irradiation which could lead to the approval of the process for specified uses within the European Community.

One should also recognize the increasing number of countries which are researching the process, or have approved it, or are applying it, to protect or conserve their food supply. Over 60 countries have active research and development programmes, while 12 countries have food irradiation research centres. A total of 40 food products or food groups have been approved in one or more of nearly 40 countries. Only a few countries prohibit or have a moratorium on its use. In January 1990, the government of the United Kingdom established regulations to allow food irradiation for eight food groups. As noted earlier, some 24 countries are applying the process to food or food ingredients.

The steady growth of membership in ICGFI is another signal that governments want information, and are considering commercialization. Governments, industry, consumer groups and professional association all need good information in order to make informed decisions. This is the primary role of the Consultative Group. All parties, whether for or against irradiation, can benefit from the activities and information generated by the Group.

The significance of the Codex General Standard on Irradiated Foods should also be underlined. The adoption of this standard by the Codex Alimentarius Commission in 1983 gave international recognition and credibility to the benefits and safety of food irradiation. The Codex consensus has lead to greater harmony among national regulations and has stimulated commercialization. Subsequent collaborative actions by WHO, IAEA, FAO and the International Consultative Group have provided additional support - i.e. codes of practice, guidelines, training and source of information. Wise application of these resources in an open, and public manner will lead to the successful introduction of new irradiation facilities and to global trade in irradiated foods.

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# THE CONTRIBUTION OF FOOD IRRADIATION TO FOOD SAFETY AND SECURITY

F. KAFERSTEIN
Food Safety Unit, World Health Organization, Geneva

*Presented by G. Moy*

**Abstract**

One of the objectives of the World Health Organization (WHO) is to assist efforts throughout the world to provide safe and nutritious food supplies. However, the safety and nutritional quality, as well as the mere availability of our food, is constantly threatened by contamination, infestation and deterioration.

Efforts to reduce the devastating consequences of food spoilage and foodborne disease started well before the first written records. Probably the first method ever used, and one still widely employed throughout the world today, was sun-drying - simple, cheap and highly effective. In the course of tens of thousands of years, people have discovered many other methods of preserving food - salting, cooking, smoking, fermentation, canning, freezing, and preservation by chemicals.

The most recent addition to this list is irradiation, i.e. the exposure of foods to carefully measured amounts of ionizing radiation. The paper will highlight the contribution this technology is expected to make with regard to the prevention of foodborne diseases and food losses.

For many years now, the World Health Organization (WHO), jointly with the Food and Agriculture Organization of the United Nations (FAO) and the International Atomic Energy Agency (IAEA), has been collaborating with scientists working in the field in food irradiation. As early as 1961, a meeting on the wholesomeness of irradiated food was jointly organized by the three agencies in Brussels. Since then, seven international meetings have been held, mainly - but not exclusively - in collaboration with FAO and IAEA.

At first glance, this rather heavy involvement by a health organization in a technological process might be surprising. However, it is quite understandable given that the process of food irradiation produces two effects that are highly beneficial to the health and well-being of mankind, namely: (i) the prolongation of shelf-life of food by killing pests and by delaying the deterioration process, thus increasing the food supply, and (ii) the destruction of certain foodborne pathogens, thus making the food supply safer. The food irradiation process has, therefore, a potential to help in the achievement of one of the essential elements of Primary Health Care, i.e. the promotion of a safe food supply and proper nutrition.

Many people in industrialized countries, hearing and reading frequently about the problems caused by agricultural over-production in their countries, appear to have difficulty in accepting that there is a need to further increase our food supply. Admittedly, if one sees these problems from the narrow, rather selfish rich-country/rich-man perspective, there appears - in the light of Western "meat mountains" and "milk lakes" - to be no logic in proposing a further increase of our food supply. However, from a global perspective, things look completely different. At the beginning of this century, our globe was inhabited by about 1.5 billion ($1.5 \times 10^9$) people. At the end of this century, the global population might exceed the six billion mark. And it is predicted that the world population increases still much higher during the early part of the 21st century before a stabilization can be expected.

All these people need to be fed, and we - all of us - have a moral obligation to utilize all our skills and technologies to increase not only food production but also to limit food spoilage. There are no exact data on how much of the world's food supply is spoiled annually but losses are enormous, especially in developing countries where, often, a warm climate favours the growth of spoilage organisms and hastens the deterioration of stored food. In such countries, the estimated storage loss of cereal grains and legumes is at least 10%. With non-grain staples, vegetables and fruits, the losses due to microbial contamination and spoilage are believed to be as high as 50%. In commodities such as dried fish, insect infestation is reported to result in the loss of 25% of the product, plus an additional 10% loss due to spoilage. With a rapidly expanding world population, as explained a little earlier, any preventable loss of food is clearly intolerable.

WHO is not suggesting that these enormous losses may be prevented by irradiation. WHO feels, however, that food irradiation technology should be given a chance so that we can learn if and to what extent food losses can be prevented by applying food irradiation, thus, making a contribution to food security.

However, the loss of edible food is only one issue of the problems related to our food supply. In 1983, a Joint FAO/WHO Expert Committee on Food Safety concluded that foodborne disease, while not well-documented, was nevertheless one of the most widespread threats to human health and an important cause of reduced economic productivity.

Generally speaking, foodborne diseases - which are caused by agents that enter the body through the ingestion of food and which are usually either toxic or infectious in nature - can be caused by either chemically or biologically contaminated food. Many people, particularly in industrialized countries, fear to be poisoned by chemicals in food, chemicals which may be found either in the form of food additives or in the form of residues from the application of various agricultural chemicals such as pesticides and veterinary drugs in food production, or in the form of so-called environmental chemicals. Based on available data, however, this fear is - by and large - unfounded.

In the 1988 German Nutrition Report, published by the German Society for Nutrition on behalf of both the Ministry of Health and the Ministry of Agriculture, the following conclusion regarding chemicals in food can be found: "According to the available data, there is no recognizable risk for the health of consumers resulting from the consumption of food containing residues or contaminants. Although - for theoretical reasons - there is no absolute guarantee for the inertness of these unwanted substances, the probability for damage to occur is, however, negligibly small. The risks for a foodborne health damage due to other reasons are much greater". While the situation in most developing countries might, unfortunately, not be as clear-cut as in Germany and, for that matter, in other comparable industrialized countries regarding chemicals in food, it remains a fact that the chances of a foodborne health risk due to other, non-chemical reasons are also much greater in the developing countries.

But let us look at what other reasons are responsible for a foodborne health damage: Besides the well-known health problems caused by mal- (that is, over- or under-) nutrition, the biological contamination of the food (and water) supply is causing, annually, possibly as many as one thousand five hundred million episodes of diarrhoea and other foodborne disease, as well as culminating in four to five million deaths. While many of these cases are related to infant diarrhoea, the non-infant population also has a very heavy burden to carry regarding such foodborne diseases as salmonellosis, campylobacteriosis, yersiniosis, hepatitis A, shigellosis and diseases caused by *Staphylococcus aureus*, *Bacillus cereus*, and *Clostidium perfringens*, as well as other foodborne microorganisms. This burden, as the following graphs show, has increased during the last 20 to 25 years. Graphs No. 1 and 2 depict the situation in Germany from 1910 to 1944, and in the Federal Republic of Germany from 1946 to 1989, and compares typhoid and paratyphoid fevers with salmonellosis and other forms of infectious enteritis. These two graphs show clearly that with increasing standard of living, the diseases like typhoid and paratyphoid fevers decrease, while diseases like salmonellosis and other forms of infectious enteritis increase rather dramatically.

Typhoid and paratyphoid fevers are diseases of undernourished, poor people living in unhygienic conditions. Salmonellosis and diseases caused by the other forms of infectious enteritis appear, at least in industrialized countries, to be the other side of the coin, called "affluence", and are related to increased consumption of food of animal origin as well as to the dramatic socio-cultural changes which many societies have experienced in the last decades.

Data concerning salmonellosis and other foodborne diseases from the UK (graphs 3 and 4), the USA (graph 5), Venezuela (graph 6) and a country in South-East Asia (graph 7) are very similar.

While the framework of this paper does not allow us to examine in detail the various factors responsible for this rather frightening development, two points still need to be made:

(1) The data reflected in the official health statistics are nothing but the tip of the iceberg. WHO has reason to believe that the actually occurring foodborne morbidity is 10-20 times greater than the reported morbidity.

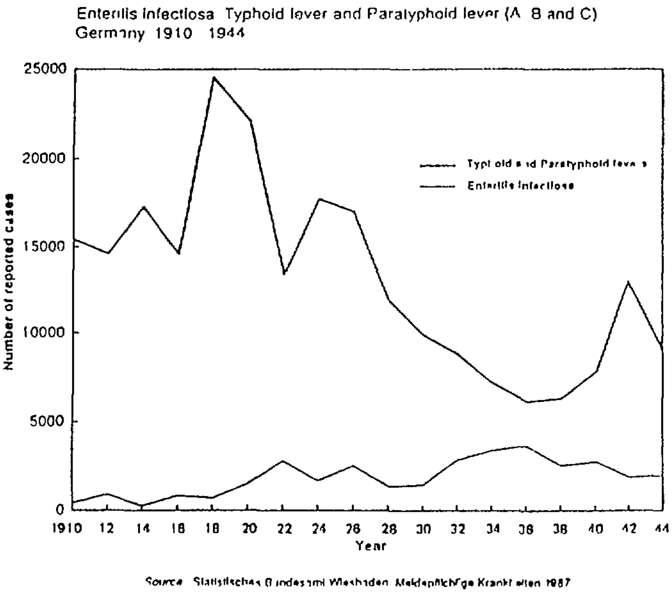
(2) In countries where reasonably good epidemiological services are operating, poultry meat has been identified as the vehicle mostly responsible for causing foodborne salmonellosis and possibly also campylobacteriosis.

Both foodborne pathogens are sensitive to an irradiation treatment in the order of up to 7 kGy. The irradiation of poultry meat is expected to obtain similar results for public health as has the pasteurization of milk. Milkborne salmonellosis was a particular health problem in Scotland. During the period from 1970 to 1982, more than 3 500 people fell ill and 12 of them died. After the introduction of milk pasteurization in Scotland in 1983, milkborne salmonellosis virtually disappeared and could only still be observed in the farming population which continued to drink raw milk. A Task Force on the Use of Irradiation to Ensure Hygienic Quality of Food concluded that at present, and in the foreseeable future, no known technology can guarantee the production of certain raw foods such as poultry or pork to be free from certain pathogenic microorganisms and parasites. Therefore, this Task Force believed that where such foods are important in the epidemiology of foodborne diseases, irradiation treatment must be seriously considered.

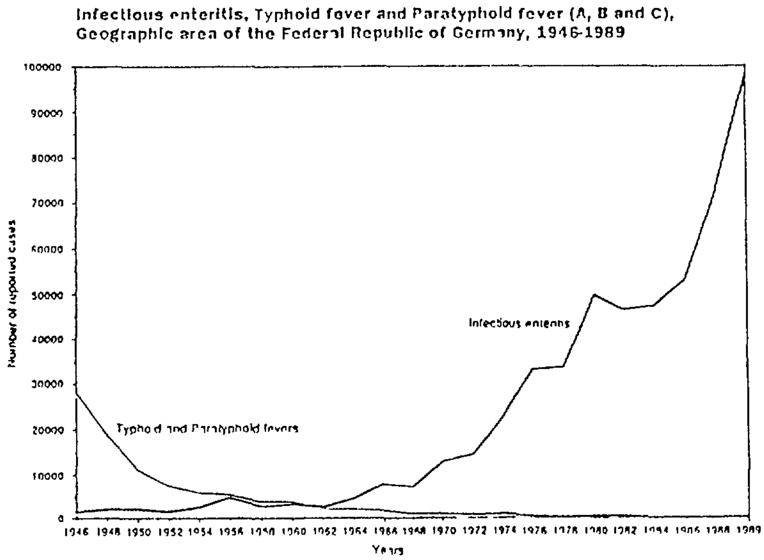
WHO has incorporated this recommendation into its Golden Rules for Safe Food Preparation. The first of these ten Golden Rules advises the consumer to purchase foods processed for safety and gives as example the recommendation to buy pasteurized as opposed to raw milk and to select fresh or frozen chickens which were treated with irradiation.

Since of all ten Golden Rules only one refers to irradiation, it is obvious that this technology can't be expected to produce miracles. For this and other reasons, WHO has time and again stressed (also in its recently published book on this subject) that food irradiation may not be seen as a panacea to all the various food safety and - as discussed earlier - food security problems mankind is facing. However, if given a chance, it will soon be seen how much contribution it can make.

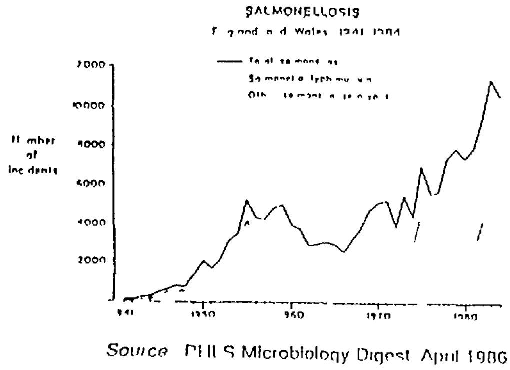
During the 1988 International Conference on the Acceptance, Trade in and Control of Irradiated Food, the four sponsoring Organizations - FAO, IAEA, ITC and WHO - had invited all participants to a cocktail party featuring a variety of irradiated foods, ranging from irradiated shrimp to potato chips produced from irradiated potatoes. The observers from a non-governmental organization (NGO) boycotted all this food since, as they put it, there was no choice between irradiated and unirradiated food. As the discussion goes on in several countries, it appears that some NGOs aim at imposing the "no-choice option" upon all of us. If it goes according to their wishes, any consumers who might prefer to purchase irradiated - and therefore pathogen-free - chicken, to give an example, will not have the choice of doing so. We will have to continue buying unirradiated - and, therefore, possibly pathogen-containing - poultry. With my paper, I have tried to provide convincing evidence that this might not be in the best interest of the people.



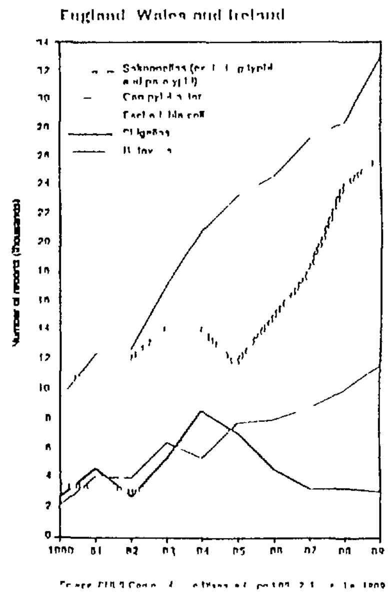

*Graph 1*



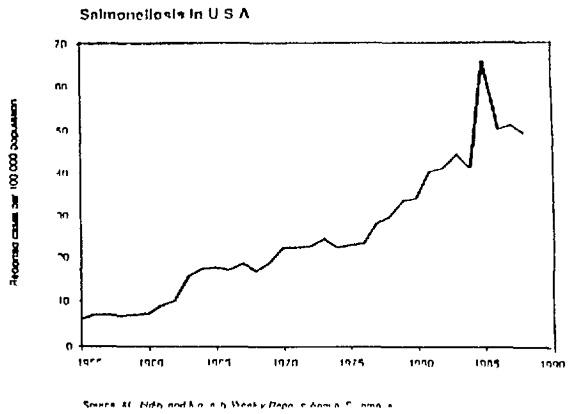

*Graph 2*



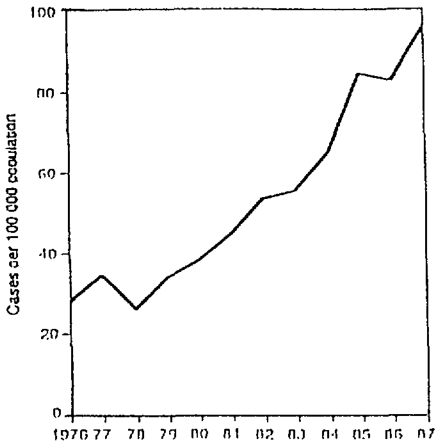

*Graph 3*



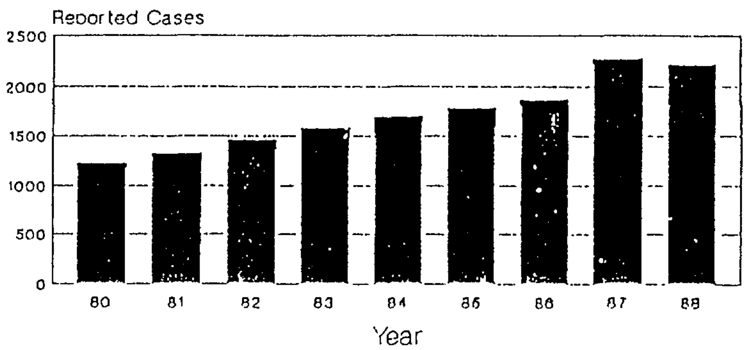

*Graph 4*




*Graph 5*




*Graph 6*




Less than 1% of the actual cases are believed to be reported.

*Graph 7*

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FOOD IRRADIATION —
TRENDS IN COMMERCIAL APPLICATIONS

(Session II)

**Chairman**

**HAJJAH AZIZAN BTE AIYUB GHAZALI**
Malaysia

# FOOD IRRADIATION TECHNOLOGY — TRENDS AND PROGRESS IN ITS COMMERCIAL APPLICATION

J. LEEMHORST
Gammaster,
Ede, Netherlands

**Abstract**

In a short historical overview, the development from laboratory use of X-ray machines to large scale industrial irradiation facilities is given. A comparison between machine sources and isotope sources is made and advantages and disadvantages of each are discussed.

Technical considerations in irradiator designs like penetration depth, dose uniformity ratio, dose distribution, product dimensions, process parameters, etc. and the limits in optimalization of process conditions are presented.

The economics of scale play an important role in radiation processing. The high initial investment and the skilled staff required to operate an irradiation facility can only be economically justified by the irradiation of large volumes. The dependence on (seasonal) availability of food products and the still limited application of the food irradiation processes are discussed. A typical multi-purpose irradiator, the pallet irradiator, will be presented and major aspects of operation are considered.

Principles of Good Manufacturing Practices and Good Irradiation Practice and its practical implications for food irradiation are discussed.

The influence of population growth, industrialization, social and cultural developments on the actual and future application of the food irradiation process will be discussed and an attempt will be made to identify important trends.

## Introduction

It is a pleasure and an honour for me to give a presentation at this seminar. The dissemination of knowledge on food irradiation is an important activity, necessary to achieve acceptance and application of this valuable process. I would have been happy had my contribution to this seminar been an impressive summary of progress made in different aspects of commercial application. However, while there has been much progress in several complementary fields, in the practical application of the technology, not much progress can be reported. Commercially irradiated volumes of food are still small and are insignificant when compared with the volumes treated in other processes.

In my presentation, I will inform you about the general progress made in the technology and identify some particular technical innovations. I will share with you some observations on the factors which influence the commercial application and finally I will try, together with you, to identify some trends which can have a positive influence on the commercial application.

## Radiation technology

In industrial applications, gamma-rays and beta-rays (accelerated electrons) are applied for the irradiation of a diversity of products. Both can cause ionizations in matter, but they are produced in a different way and have different properties. Gamma-rays are emitted by a radio-active isotope, mostly $^{60}Co$ and beta rays by an electron accelerator. Gamma-rays are electro magnetic waves with a short wavelength and a high energy level. Gamma-rays have similar properties to X-rays but a higher energy level and greater penetration capabilities. Depending on the acceleration voltage, beta-rays can have different energy levels, even much higher than gamma-rays emitted by $^{60}Co$. Electron sources have the advantage that they can be switched off when they are not needed.

As both gamma- and beta-rays can cause damage to organic matter, extensive measures have to be taken to ensure that unintended exposure is not possible. The construction and operation of an irradiation facility is, for this reason, subject to stringent requirements and is a costly affair.

The choice of radiation is determined by the properties of the object to be irradiated. The density of the material and the dimensions of the object determine the dose distribution. The acceptable dose uniformity ratio (the ratio between the maximum and the minimum dose received at any position within the product) is decisive for the choice. When deep penetration of a high density product is required, gamma-rays have a clear advantage. Beta-rays are typically suited for thin layer irradiation and in applications where a high dose in a short time is to be applied. In some applications, both can be used. For psychological reasons, sometimes an accelerator is preferred as the emission of radiation can easily be terminated. When in use, both irradiators require similar safety provisions.

Since the first observations of ionizing radiation by Röntgen in 1895 and Becquerel in 1896, the application of radiation has shown an impressive growth. Irradiation gained recognition as a valuable process, especially after World War II when large, high energy radiation sources became available. In addition to the well-known medical applications, radiation now is used in many industrial activities. The main application of gamma irradiation is the sterilization of medical supplies. Beta irradiation is mainly applied in cross-linking processes of plastics and for grafting. About 170 industrial gamma irradiators are in operation worldwide. Several hundreds of electron accelerators with a wide variety in energy levels are in use in different industrial activities.

In the 40 years of application, irradiation has become a mature process. There is much international agreement on the safety requirements set for facilities and on the control of the process. There is extensive exchange of knowledge and experiences amongst industry and government. Application of the process is in accordance with international standards and a Code of Practice.

The construction of special food irradiators is still not feasible, due to the limited demand. In general, standard industrial irradiators are used. Sometimes special provisions allow the application of small doses used in some food irradiation processes. With the exception of one accelerator in France and some pilot facilities, most foods are irradiated in multi-purpose irradiators.

For the gamma irradiation process, the pallet irradiator offers the most economic and flexible multi-purpose operation. While normal transport units are used in the process, labour involvement is limited. The application of an incremental dose control system makes it possible to treat a variety of products with different doses and densities without losses in efficiency. Multi-purpose pallet irradiators are operated for food irradiation in the Netherlands, Germany and France. A pallet irradiator in Florida, USA, intended mainly for food irradiation, has been recently commissioned and will soon start to offer contract irradiation.

Two large 10 MeV electron accelerators, in France, are in operation for food irradiation. A producer of deboned chicken meat uses one of these mainly for the decontamination of his product but also offers irradiation services. The other unit is used in multi-purpose contract irradiation.

An innovation in electron beam processing is the use of two electron beams in line. Through the simultaneous irradiation from two sides, it is possible to irradiate objects with larger dimensions and higher densities. A facility built according to this concept, started sterilization of medical supplies in Belgium in December 1991. In Japan, an electron accelerator with the possibility of conversion of the electrons into electromagnetic waves (Bremsstrahlung) with similar properties as

X-rays was commissioned in late 1991. Both new developments can possibly have a positive impact on food irradiation.

**Wholesomeness of irradiated food**

More than 30 years of intensive study of radiation effects on all properties of foods has resulted in a wealth of knowledge. There is much more scientific evidence about the wholesomeness of irradiated foods than of foods treated by any other physical process. As stated by many scientific committees, there are no health considerations objecting to the application of the process. On the contrary, there have been many applications identified in which irradiation could replace polluting, hazardous and toxic processes. While maintaining the original properties of the product, irradiation can, in many applications, improve the safety of products which are naturally contaminated with pathogens.

**Legislation**

The recognition of the potential of the irradiation process to reduce food losses and prevent foodborne disease has led some United Nations Organizations, health authorities and leading scientists to be active promoters of the application of the process. Since the acceptance of a General Standard and a Code of Practice for the irradiation of foods by the Codex Alimentarius Commission, much progress in legislation has been made. In a number of countries, food irradiation is legalised and remaining countries can adapt these legislative systems without major problems.

**Food industry**

The food industry is well aware of the advantages of irradiation. A number of applications have been defined, in which the process offers new opportunities, has advantages above conventional processes or is complementary to existing methods. The necessary high investments in irradiation facilities are, in many situations, very well justified by the benefits.

The food industry faces many technological problems. The changing habits in food consumption, the pressure to reduce the use of chemicals and the demands to limit environmental pollution are hardly met by the existing technologies. Irradiation offers new opportunities for process and product innovations.

**Constraints on the commercial application**

(i) Clearance systems

Up till the mid-1950s, there was no legislation in place for the application of a physical food preservation process. In that time, the food industry started to use radiation for food treatment. In Germany, spices were decontaminated. In France, shelf-life extension of frozen products was achieved and in USA different food groups were irradiated. No legislation governed these applications and the industry made the first careful attempts to incorporate this new process technology. The self-regulating process prevented uncontrolled behaviour and no problems arose from this applications. The publications in that time reported successes and there were great expectations for its future use.

This development was abruptly stopped by a USSR publication of a clearance to apply irradiation for sprout inhibition. Suddenly several countries felt the urgent need to implement legislative procedures. Depending on the legal system, several procedures were imposed. In Germany, a complete ban (intended to be released when more knowledge was gained) came in place and in USA irradiated foods were, for reasons of convenience, classified as drugs.

The actions of these three countries and areas have caused a major setback in the commercial application of food irradiation. In spite of all the evidence about the wholesomeness of irradiated foods, these countries have not basically changed their attitude and their positionings, in many aspects, of food irradiation are still amongst the major obstacles. The clearance system, adapted in USA and followed by many other countries, with an array of requirements and the opposition of Germany to the harmonisation of food irradiation legislation in the European Community, hampers large scale application of the process.

(ii) Comparison with legislature applicable to other physical processes

When a comparison with other food preservation processes is made, it is astonishing how few requirements are in place for so called conventional processes and how many are in place for irradiation.

In spite of the well-known fact that heat treatments seriously affect the properties of foods, that essential nutrients are lost and that all kinds of undesired chemical reactions can occur, almost no limitation is set to the application of these processes. I am not aware of any legislation required for the application of heat to foods nor of any foods that may not be exposed to heat.

A similar observation can be made with regard to other preservation processes like cold treatment and drying. Even the addition to foods of highly aggressive chemical compounds like salts, spices and acid is not subject to a strict group of regulations.

The application of stringent legislatory procedures in food irradiation is sometimes justified by pointing out that irradiation is a new process and that in our modern society new processes are subjected to scrutiny in accordance with the state of our knowledge.

I could appreciate this, except that within the last few years, another process, the "microwave" treatment of foods, has gained rapid acceptance with little objection or regulated application.

Is there any rational reason justifying such different attitudes?

Seen from the technological viewpoint, irradiation and microwave treatment have much in common. In both processes, high energy radiation is used and precautions have to be taken to prevent unintended exposure to each radiation. Only the energy levels differ and exposure to the kind of radiation used in food irradiation can cause more damage. That the effect of microwave treatment on the food is so similar to the known heat treatment, that it has obvious benefits to the public and application in the home kitchen, perhaps offers an explanation for the unconditional acceptance by that public but not for the almost complete absence of regulations in the application of microwave treatment.

**Political support**

The public has a negative perception of food irradiation. Associations with concepts such as nuclear, radioactive contamination, radiation hazards, etc. often cause a rejection. This negative judgement is clearly reflected in the positioning of groups and persons representing the community. Representatives of the community, exposed to the judgement of the public, rarely if ever dare to commit themselves to food irradiation. They will always have some reservations and their continuous demands for more research, more controls and more certainties will probably never be met in full.

Officials on national and international level, which are less exposed to the public, are mostly willing to support the application. Under pressure of community representatives (politicians, consumer organizations, opponents, etc.), they request the strictest controls on the process. To avoid any possibility of misuse or hazard, an array of laws, regulations, obligations, restrictions, etc. is produced. The actions of all parties have a cumulative negative influence on the commercial application of the process. The stringent requirements applied to food irradiation support the fears of the public and causes suspicion and rejection. The field of force, dominated by rejection and constraints, is not the environment in which a commercial activity prospers.

Contrary to what sometimes is supposed by opponents, food irradiation has no political support or lobby. The small industrial irradiation activity is subject of political considerations and rational considerations play only a subordinate role.

**Trends**

The application of irradiation in industry shows a continuous growth. As a clean process, not leaving any residues in a treated product, application is no burden to the environment. Irradiation is often an alternative for processes which are banned or restricted in application for environmental reasons. It may be expected that acceptance of commercial irradiation in other applications will also have a positive influence on food irradiation.

More than 40 years of threat with nuclear weapons has caused an emotional rejection of everything that was suspected of a relation with nuclear. Now that this threat is less dominant, a change in attitude can be observed. People are becoming more rational in their judgements. This changing attitude makes them more receptive for information on the benefits offered by food irradiation. Still, a major educational effort will be required to overcome emotional fears.

The growing international trade makes it necessary that laws and regulations become harmonized. This requirement, together with higher demands for knowledge of the many aspects of products in trade, results in more legislative requirements.

**Summary**

A number of constraints still hamper commercial food irradiation. Most progress has been achieved in legislation and in technology. There are trends which could stimulate commercial food irradiation but that will require a long time and a major effort in the education of the public. A much faster growth could be achieved if leading countries would adapt their legislature to incorporate the positive evidence on the wholesomeness of irradiated foods.

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# DEVELOPMENT OF FOOD TRADE IN THE ASIA AND PACIFIC REGION AND PROSPECTS FOR COMMERCIAL APPLICATION OF FOOD IRRADIATION

B. OLSEN
International Trande Centre,
UNCTAD/GATT, Geneva

## Abstract

The paper will briefly analyse the Asia and Pacific Region's position in international food trade, giving details of the Region's exports of food products to the world and the internal trade in food products of the region. The paper will identify export products which can be seen as the most likely candidates for food irradiation. Furthermore, tariff and non-tariff barriers effecting a decision on the use of food irradiation for export products will be discussed. In major import markets, consumer group resistance continues to negatively effect the attitude and acceptance of the trade to deal in irradiated food products. Could the development of national and regional trade in selected irradiated food products represent a basis for a gradual, universal development of trade in these products?

## Introduction

The paper will briefly analyse the Asia and Pacific region's position in international food trade, giving details of the region's exports of food products to the world and the regional trade in food products of the region. The paper will identify export products which can be seen as the most likely candidates for food irradiation. Furthermore, tariff and non-tariff barriers effecting a decision on the use of food irradiation for export products will be discussed. Some consideration is given to the potential for developing an export trade for selected food items. In major import markets, consumer group resistance continues to negatively effect the attitude and acceptance of trade in irradiated food products. The development of domestic and regional trade in selected irradiated food products could represent a basis for a gradual, universal development of trade in these products.

## Food trade of Asia and the Pacific countries

In order to fully appreciate the importance of food exports from Asia and Pacific countries, a few basic figures are given in Table 1. As can be seen from this table, world trade (imports) in food products amounted to about US$231,000 million in 1990, of which selected Asian countries supplied about US$19,000 million and the ASEAN countries US$11,000 million. The main target markets for Asian countries are Japan 29.6%, the EEC countries if seen as a single market 23.7%, the United States 15.4% and Hong Kong 12.2%. The relative importance of the individual target markets are set out in Chart 1.

Table 2 shows the relative importance of the selected Asian countries' supplies of food products to the world, with China and Thailand as the leading suppliers with US$6.0 and 5.5 billion of food exports respectively, and Indonesia, India, the Philippines, Malaysia supplying between US$1.3 and 2.0 billion each.

## Product analysis

In relation to the prospects for food irradiation, it is important to analyse the product composition of the food exports. Table 3 gives an overview of food exports by product from Asian countries. Commodities exported in the raw or semi-processed form such as fresh or frozen shrimps and fish, fresh fruit and vegetables, vegetable oils and oil cakes, rice, meat, cocoa, coffee and spices, are the main food export items from the region.

Table 4 shows the destinations of the main food items exported from Asian countries. In descending order of importance, the products in which there is a substantial international trade and which could be considered for irradiation, the following should be mentioned:

1. Fish and shrimps, fresh or frozen

2. Fresh fruits and vegetables, and dried fruits and nuts

3. Meat, fresh, chilled or frozen

4. Rice

5. Cocoa

6. Spices

More detailed analyses of three product groups, namely crustaceans, fresh fruit and vegetables and spices, are given below.

(i) Crustaceans

Chart 2 shows that one third of total world supplies of crustaceans originate in Asian countries. The main supplying countries are China, Thailand, Indonesia and the Philippines. Japan is by far the biggest market (more than 50%) followed by the United States, EEC and Hong Kong. Considering the importance of exports of crustaceans from the region, this item should be given special attention in relation to possibilities for applying the irradiation processing.

When considering the possibilities for commercial application of food irradiation in countries exporting crustaceans, it is of vital importance to be well informed about the market access situation in the main target markets. In the fish and shrimp import trade in the main consuming/importing countries, the general feeling is that if the product is properly handled from the catch or farming, immediate and sufficient application of ice or freezing, high sanitation standards at all stages of the processing and with an outbroken freezing chain, the product should meet the quality requirements of the importing country and there is basically no need for irradiation.

Reportedly, some importing countries in Europe irradiate shrimps. Considering that 90% or more of all shrimps enter the consumer market without irradiation, it seems legitimate to ask why some quantities of shrimp were irradiated at all. In fact, the trade is rather sceptical, and tends to associate an irradiated shrimp with a product that did not meet the generally accepted quality levels before irradiation was undertaken. If this is the case, the overall image of the irradiation process, as a means of providing safe food, has a tendency to suffer and the trade and industry, in general, will not like to be associated with the process.

In the case of frogs' legs which, to a large extent, are traded through the same trade channels, the need for irradiation is pronounced in the light of the high bacterial level in the raw product. Irradiated frogs' legs are marketed in France, the main market for this product. However, total world trade in this item is small.

(ii) Fruit and vegetables and nuts

In 1990, the volume of exports from the Asian region of fresh and dried vegetables, roots and tubers, amounted to US$1.7 billion. Thailand and China were the main suppliers. Fruit and nut exports amount to US$1.2 billion with the Philippines, China and Indonesia as the main suppliers. EEC, Japan and Hong Kong are the main destinations of the exports. The big volumes of exports of fruit and vegetables and nuts certainly would justify a close monitoring of the possibilities and appropriateness of using irradiation, for example, as an alternative to the current methods of quarantine treatment, shelf-life extension or sprout inhibition. Government clearance has been given for many of the products in consuming importing countries and, in some of them, small quantities of selected fruit and vegetables are being irradiated and marketed domestically. The introduction of increasingly stringent requirements on chemical residues should further enhance the possibilities for irradiated products. However, the reluctance of the trade and industry to embark on food irradiation in a big way continues to be effected by the possibilities for negative publicity from consumer groups or competitors.

(iii) Spices

Close to 50 per cent of world imports of spices (US$480 million) is supplied by Asian countries. The biggest exporters from the region are Indonesia, China, Malaysia and India. The main import markets are the United States, the EEC (if seen as a group) and Japan. Trade in irradiated spices is approved by most of the governments in these markets. For spices, the irradiation process offers many advantages over the traditional processing methods, particularly with regard to providing safe food. In spite of this seemingly very positive situation for the development of an international trade in irradiated spices, there has not been a real breakthrough. The reasons for this lack of response by the trade and industry are complex and irrespective of scientific evidence of the superiority of the irradiation method, no major spice processor, packer or trader has decided to officially declare that they use the method or trade in irradiated spices on a broad basis. On the contrary, some of the major spice companies have declared that they are not irradiating spices nor trading in irradiated spices. The main reason for this position is the strong pressure from consumer groups.

In the major consuming markets, about 50-60 per cent of the spices are currently consumed by industrial users, meat processors, bakeries, etc. Except for Denmark, there is no legislation enforcing that the label on the final product should inform the consumer if the spices used are irradiated. In principle, therefore, consumers will not be able to identify whether the spices used in the product were irradiated or not and a negative consumer reaction should not be expected. An overriding condition of the food industry is that the spices they use in food processing are 100 per cent safe. Food processors pay for this safety which is normally ensured by the well-established spice industry situated in consuming countries. Taking into consideration the requirements of safety in the food industries, it would have been interesting to research the food industry's attitude to the use of irradiated spices.

**Tariff and non-tariff barriers**

(i) Tariff barriers

An analysis of the customs tariff structure clearly indicates that the tariff levels for raw or semi-processed products originating in developing countries are either nil or low (less than 10% ad valorem). Thus, in most cases, tariff barriers do not represent a hindrance to trade. However, preferential treatment given to groups of countries, for example, the preference given by the EEC to APC countries, certainly provides the latter with a competitive advantage over other suppliers and with influence trade flows. Another aspect of tariff structure is that on processed foods, the tariff level can become a considerable barrier to trade. For example, in the case of the EEC, the common external tariff for processed fruit and vegetables ranges between 20-30 per cent ad valorem and in addition to the duties, there might be levies such as a sugar levy which, under certain circumstances, can become very important. In the case of the United States, the range of customs tariffs on processed fruit and vegetables is also considerable and might be as high as 30%. Both in the case of the EEC and Japan, there are preferential schemes giving considerable concessions to developing countries. However, the basic conclusion is that there is a tariff escalation in relation to the degree of processing of the product. This might lead to a considerable disadvantage to producers/exporters in developing countries. It should therefore be cautioned that if food irradiation is considered as a new method of food processing for which a specific tariff classification is introduced, this could also open to the introduction of a new set of customs tariffs. However, for the time being, this is only an hypothetical situation which should be monitored in the future.

(ii) Government non-tariff barriers

In the case of food products, government non-tariff barriers can include:

- special levies on processed products which include products which are grown or produced in the importing country. The EEC and

North America have used such levies to regulate both the quantities of processed foods and the degree of intensity of their processing

- quotas, embargoes and import licensing which are either to protect domestic industry, including agriculture, or to dampen down consumption for balance of payments purposes. Japan has been a user of this type of non-tariff barrier in the case of processed foods.

- health regulations with stringent quality requirements which are justified both in terms of enhancing hygienic quality and reducing the levels of harmful residues from chemical additives, fumigants, pesticides, herbicides and fertilizers. They can, however, be so complicated and restrictive that they act as a disincentive for developing country suppliers

There is a general tendency to tighten phytosanitary regulations, often supported by consumer groups. In the case of the United States, the Food and Drug Administration (FDA) are rigorous in their testing and rejection of imported food products are common. Such rejection can, in some cases, prove costly to developing country suppliers because often an entire consignment will be incinerated as a result of non-conformity to regulations. Japan has a very strict food sanitation act which stipulates that edible foods must not contain certain synthetic additions or agricultural chemical residues. Furthermore, all additives have to be clearly indicated on the label. There are a myriad conditions and restrictions on the import of processed foods into Japan and the market has historically been restricted, although it is believed that the situation is now changing. Although the EEC countries are in the process of harmonizing their regulations governing the imports of food products, still one experiences considerable differences in the import regimes between countries.

As an example, some years ago, Honduras experienced a very strange situation with their exports of tropical oranges. Originally, the destination was Germany but because of the interpretation of some of the rules, the imports were not allowed and the products had to be re-directed to the Netherlands where import could take place.

Sometimes, when a pest occurs, prohibited chemicals or other foreign substances have been found in the food, a complete embargo on exports from that country can ensue.

It is not really the existence of strict import controls that limits the demand for the produce from developing countries, but essentially their ability to meet the extra costs involved in adhering to those controls and yet be competitive with countries and companies which are able to do so.

Another non-tariff barrier which is linked to the hygiene and health controls is that of packaging and labelling. Many countries have very precise requirements concerning the types of packs that are acceptable and the details that labels must contain. New hygiene requirements often stipulate specific types of packaging and often the labelling must contain precise details of all ingredients, their percentage inclusion in the products, and their source. Many countries also require labels to be printed in their own language and where this involves a different alphabet and phonetics, it can pose problems to developing country producers. This is particularly so far Middle Eastern import markets and Japan.

Failure to adhere to these rules can cause a refusal to allow the importation of a consignment, and even an embargo on produce from the supplying country until packaging and labelling is acceptable. The solution is one of obtaining the appropriate information from the target market and work with small test consignments, but once again, the problems of profitability arise in terms of the extra cost involved in printing new labels and providing new, more sophisticated packaging.

**Interregional trade**

Analysis of the potential for developing an international trade in irradiated food products between the Asian suppliers and the main consuming markets has indicated that there are certain difficulties in achieving such a trade. On the other hand, within some consuming markets such as the Netherlands and France, irradiation is increasingly applied for some food items. Although irradiated foods cannot be identified in trade statistics, it is believed that commercial irradiation facilities in the EEC are serving domestic and some other EEC markets. Similarly, one could conclude that although the development of international trade is irradiated food is a very slow process, the development of the national or regional trade in these products is subject to fewer obstacles. Statistics covering the regional Asian trade in food products show that food exports from some countries such as Thailand, China, Malaysia, Indonesia and India to the regional market is considerable. The development of a domestic or regional trade in irradiated food in Asia and the Pacific might, therefore, be easier than attacking the main international consuming markets. Scientific evidence of the appropriateness of applying irradiation to certain foods as an alternative to traditional treatment or processing methods to obtain safe food, and government approval of irradiation for certain foods, does not seem to suffice for the development of international trade in irradiated food. Consequently, an approach to the development of this trade seems to be the establishment of a domestic market for some of the key items such as chicken and some national dishes, and then gradually expand the trade to the neighbouring markets. Trade statistics show that fresh fruit and vegetables, fish, meat, spices and rice are the most traded items with a potential for irradiation within the Asia and Pacific region.

Table 1

World imports a/ of food products and share of supplies from selected Asian countries, 1990 (in US$ million)

| Importing countries | Total World | From selected Asian countries b/ Value | From selected Asian countries b/ % of total world | From ASEAN countries Value | From ASEAN countries % of total world |
|---|---|---|---|---|---|
| WORLD | 231,413 | 19,177 | 8 3 | 10,981 | 4 7 |
| of which | | | | | |
| Japan | 30,221 | 5,685 | 18 8 | 3,175 | 10 5 |
| EEC | 130,012 | 4,547 | 3 5 | 2,787 | 2 1 |
| Germany, Fed Rep | (30,370) | (1,131) | (3.7) | (753) | (2 5) |
| Netherlands | (13,645) | (802) | (5 9) | (621) | (4 6) |
| United Kingdom | (19,065) | (697) | (3 7) | (311) | (1 6) |
| France | (19,693) | (621) | (3 2) | (358) | (1 8) |
| Spain | (8,296) | (364) | (4.4) | (225) | (2 7) |
| Italy | (18,405) | (356) | (1 9) | (173) | (0 9) |
| Belgium Luxembourg | (10,119) | (206) | (2 0) | (141) | (1 4) |
| Others | (10,419) | (370) | (3 6) | (205) | (2 0) |
| United States | 24,165 | 2,952 | 12 2 | 2,041 | 8 4 |
| Hong Kong | 4,631 | 2,341 | 50 6 | 607 | 13 1 |
| Korea, Rep. of | 3,532 | 417 | 11 8 | 363 | 10 3 |
| Canada | 6,386 | 323 | 5 1 | 185 | 2 9 |
| China | 3,479 | 147 | 4.2 | 142 | 4 1 |
| Mexico | 3,870 | 126 | 3 3 | 46 | 1 2 |
| Switzerland | 3,400 | 94 | 2 8 | 56 | 1 6 |
| Others | 21,717 | 2,545 | 11.7 | 1,579 | 7 3 |

Source COMTRADE Data Base of the United Nations Statistical Office

a/ Excluding imports into Saudi Arabia, Egypt, Algeria, Brazil, Malaysia, Czechoslovakia, Peru, Kuwait, Poland, Thailand, India, Pakistan, Philippines, Bangladesh, Morocco, Jordan, Syria and Sri Lanka.

b/ ASEAN countries (Indonesia, Malaysia, Philippines, Singapore, Thailand, Brunei), and China, India, Pakistan and Sri Lanka

Table 2
Exports of food products by selected supplying countries in Asia, 1990 a/ (in US$ million)

| Origin | Value | % of total |
|---|---|---|
| TOTAL WORLD | 231,413 | 100 0 |
| of which from | | |
| Selected Asian countries, total | 19,177 | 8.3 |
| of which ASEAN countries, total | (10,981) | (4 7) |
| China | 6,060 | 2 6 |
| Thailand | 5,480 | 2 4 |
| Indonesia | 2,006 | 0 9 |
| India | 1,593 | 0 7 |
| Philippines | 1,499 | 0 6 |
| Malaysia | 1,369 | 0 6 |
| Singapore | 627 | 0 3 |
| Sri Lanka | 284 | 0 1 |
| Pakistan | 259 | 0 1 |
| Brunei | | - |

Source COMTRADE Data Base of the United Nations Statistical Office
a/ Based on import figures

Table 3 Supply of selected food products from Asian countries a/ in 1990 (in US$ million)

| SITC 2 | Product | World Imports | From selected Asian countries | Major suppliers and % of total supplies from selected Asian countries |
|---|---|---|---|---|
| 036 | Crustaceans and molluscs, whether in shell or not, fresh, chilled, frozen, salted, in brine or dried, crustaceans in shell, simply boiled in water | 11 937 | 3,953 | China 29 7, Thailand 26 8, Indonesia 16 9, India 12.4, Philippines 7 2, Malaysia 3 0 |
| 054 | Vegetables, fresh, chilled, frozen or simply preserved (including dried leguminous vegetables), roots, tubers and other edible vegetable products, n e.s fresh or dried | 16,850 | 1,663 | Thailand 50 0, China, 37 5, Indonesia 8 3 |
| 057 | Fruit and nuts (not including oil nuts), fresh or dried | 21,342 | 1,253 | Philippines 38.3, China 24 6, India 17 7 Malaysia 7 1, Thailand 6 7, Sri Lanka 2 8 |
| 061 | Sugar and honey | 8,167 | 1,040 | Thailand 53.3, Philippines 14 8, China 11 8, Pakistan 8 1, Malaysia 5 1, India 3 3, Indonesia 3 0 |
| 034 | Fish, fresh (live or dead), chilled or frozen | 15 169 | 972 | China 36 0, Thailand 21 7, Indonesia 12 7, Singapore 12 0, Malaysia 6 9, Philippines 5 8, India 3 8 |
| 081 3 | Oilcake and other residues (except dregs) resulting from the extraction of vegetable oils | 5,531 | 785 | China 34 1, India 26 6, Malaysia 15 6, Indonesia 12 0, Philippines 10 2 |
| 041 | Wheat and meslin, unmilled | | | |
| 042 | Rice | | | |
| 043 | Barley, unmilled | 19,867 | 783 | Thailand 60 3, China 25 8, India 9 1, Pakistan 4 2 |
| 044 | Maize (corn), unmilled | | | |
| 045 | Other cereals, unmilled | | | |
| 222 | Oilseeds and oleaginous fruit, whole or broken, of a kind used for the extraction of "soft" fixed vegetable oils | 9,566 | 632 | China 80 4, India 14 1 |
| 011 | Meat and edible meat offals, fresh, chilled or frozen | 26,686 | 629 | Thailand 53 2, China 41 2 |
| 072 | Cocoa | 3,903 | 559 | Malaysia 57 5, Indonesia 18 4, Singapore 15 8, Philippines 4 1, China 3 6 |
| 071 11 | Coffee, not roasted, coffee husks and skins | 7 216 | 530 | Indonesia 63 7, Thailand 18 7, India 13 4 |
| 075 | Spices | 1,121 | 480 | Indonesia 32 2, China 19 3, Malaysia 14 1, India 13 9, Sri Lanka 7 0, Thailand 6 9, Singapore 4 9 |
| 075 1 | Pepper and pimento | (488) | (246) | Indonesia 29 3, Malaysia 25 4 China 17 7, India 16 2, Singapore 5 1 |
| 075 22 | Cinnamon and cinnamon tree flowers | (101) | (85) | Indonesia 34 6, China 31 8, Sri Lanka 31 4 |
| 075 24 | Nutmeg, mace and cardamoms | (74) | (43) | Indonesia 61 9, Singapore 16 7, India 10 1, Malaysia 4 7 |
| 058 5 | Fruit juices (including grape must) and vegetable juices, whether or not containing added sugar, but unfermented and not containing spirit | 4,768 | 128 | Thailand 52 8, Philippines 37 4 |
| 014 | Meat and edible meat offals, prepared or preserved, n e.s , fish extracts | 3 737 | 105 | China 69 6, Thailand 18 0, Singapore 9 6 |

Source COMTRADE Data Base of the United Nations Statistical Office
a/ ASEAN countries (Indonesia, Malaysia Philippines, Singapore, Thailand, Brunei) and China, India, Pakistan and Sri Lanka.

Table 4 Main destinations of selected food products from Asian countries a/, 1990 (in US$ million)

| SITC 2 | Product | World | Japan | EEC | USA | Hong Kong |
|---|---|---|---|---|---|---|
| 036 | Crustaceans and molluscs, fresh, chilled or frozen, salted, in brine or dried, crustaceans, in shell, simply boiled in water | 3,953 0 | 2,177 3 | 460 0 | 851 3 | 250 8 |
| 054 | Vegetables, fresh, chilled, frozen or simply preserved (including dried leguminous vegetables), roots tubers and other edible vegetable products, n e s, fresh or dried | 1,662 7 | 269 4 | 949 5 | 23 9 | 125 5 |
| 037 | Fish, crustaceans and molluscs, prepared or preserved, n e s | 1 314 9 | 213 5 | 398 1 | 477 8 | 21 0 |
| 057 | Fruit and nuts (not including oil nuts), fresh or dried | 1,253 4 | 494 7 | 152 6 | 163 6 | 236 2 |
| 081 | Feeding stuff for animals (excluding unmilled cereals) | 1,221 6 | 291 6 | 586 8 | 32 0 | 61 5 |
| 034 | Fish, fresh, chilled or frozen | 971 7 | 461 3 | 89.5 | 129 3 | 193 9 |
| 058 | Fruit, preserved, and fruit preparations | 947 5 | 159 0 | 236 5 | 290 9 | 57 2 |
| 011 | Meat and edible meat offals, fresh, chilled or frozen | 629 1 | 338 7 | 118 1 | 1 7 | 128 7 |
| 042 | Rice | 578 6 | 4 1 | 121 6 | 81 1 | 121 0 |
| 072 | Cocoa | 558 9 | 15 0 | 191 6 | 179 5 | 0 5 |
| 075 | Spices | 480 2 | 67 3 | 120 8 | 129 1 | 32 5 |
| 098 | Edible products and preparations n e s | 336 7 | 28 0 | 36 8 | 50 8 | 145 8 |
| 044 | Maize (corn), unmilled | 146 0 | 119 7 | 0 2 | | 7 1 |

Source COMTRADE Data Base of the United Nations Statistical Office
a/ ASEAN countries (Indonesia, Malaysia, Philippines, Singapore, Thailand, Brunei), and China India, Pakistan and Sri Lanka

Table 5 Main selected food products exported by Malaysia a/ into 34 major markets b/ (in US$ million)

| | Product | 1988 | 1989 |
|---|---|---|---|
| 072 1 | Cocoa beans, whole or broken, raw or roasted | 367 9 | 321 7 |
| 081 38 | Oilcake and other residues (except dregs), resulting from the extraction of palm nuts and kernels | 95 8 | 110 6 |
| 036 0 | Crustaceans and molluscs, fresh, chilled, frozen, salted, in brine or dried, crustaceans, in shell, simply boiled in water | 99 9 | 105 8 |
| 075 1 | Pepper of the genus Piper , pimento of the genus Capsicum or of the genus Pimenta ' | 80 4 | 88 0 |
| 037 2 | Crustaceans and molluscs, prepared or preserved, n e s | 45 7 | 66 3 |
| 072 32 | Cocoa butter (fat or oil) | 55 8 | 58 9 |
| 057 98 | Fresh fruit (other than citrus, bananas, apples, grapes, figs, nuts, pears, quinces, stone fruit, berries, pineapples, dates avocados, mangoes, guavas & mangosteens) | 39 6 | 52 7 |
| 058 99 | Fruits and nuts, prepared or preserved, n e s | 47 2 | 44 2 |
| 034 1 | Fish, fresh or chilled (excluding fillets) | 22 1 | 34 7 |
| 037 1 | Fish, prepared or preserved, n e s (including caviar and caviar substitutes) | 16 2 | 22 2 |
| 054 59 | Vegetables, fresh or chilled (other than potatoes, tomatoes, onions, shallots, garlic, leeks and other alliaceous vegetables) | 18 6 | 20 9 |
| 025 1 | Eggs, birds', and egg yolks, fresh, dried or otherwise preserved, sweetened or not, in shell | 21 8 | 20 6 |
| 057 71 | Coconuts, fresh or dried | 25 9 | 19 0 |
| 022 49 | Milk and cream, preserved, concentrated or sweetened, other than powder or granules | 12 8 | 12 6 |
| 034 2 | Food preparations, n e s | 12 8 | 12 3 |
| 098 04 | Sauces, mixed condiments and mixed seasonings | 8 5 | 10 8 |
| 091 49 | Imitation lard and other prepared edible fats, n e s | 2 1 | 9 1 |
| 022.43 | Milk in powder or granules, containing not more than 1 5% by weight of fat | 12 8 | 8 8 |
| 034 2 | Fish frozen (excluding fillets) | 3 1 | 6 8 |
| 072 2 | Cocoa powder, unsweetened | 4 7 | 6 6 |

Source COMTRADE Data Base of the United Nations Statistical Office
a/ Based on import figures
b/ OECD countries (excluding Turkey) and Cyprus, Ecuador, Hong Kong, Indonesia, Israel Korea Rep of Morocco, Panama, Singapore, Trinidad and Tobago, and Tunisia

Table 6 Main selected food products exported by Thailand a/ into 34 major markets b/ (in US$ million)

| | Product | 1988 | 1989 |
|---|---|---|---|
| 036 0 | Crustaceans and molluscs, fresh, chilled, frozen, salted, in brine or dried, crustaceans, in shell, simply boiled in water | 693 9 | 970 2 |
| 054 81 | Manioc, arrowroot, salep, Jerusalem artichokes, sweet potatoes and other similar roots and tubers, fresh or dried, sago pith | 713 7 | 691 4 |
| 037 1 | Fish prepared or preserved, n e s (including caviar and caviar substitutes) | 500 8 | 573 7 |
| 042 21 | Rice, semi-milled or wholly milled, whether or not polished or glazed | 227 2 | 349 5 |
| 061 1 | Sugars, beet and cane, raw, solid | 125 6 | 335 3 |
| 011 4 | Poultry, dead, and edible offals thereof (except liver), fresh chilled or frozen | 197 6 | 243 4 |
| 058 99 | Fruits and nuts, prepared or preserved, n e s | 218 6 | 240 2 |
| 037 2 | Crustaceans and molluscs, prepared or preserved, n e s | 231 4 | 223 6 |
| 081 99 | Sweetened forage, other preparations of a kind used in animal feeding, n e s | 67 3 | 149 1 |
| 034 2 | Fish, frozen (excluding fillets) | 88 8 | 108 5 |
| 044 0 | Maize (corn), unmilled | 18 8 | 62 2 |
| 054 2 | Beans, peas, lentils and other leguminous vegetables, dried, shelled, whether or not skinned or split | 40 1 | 44 2 |
| 058 54 | Pineapple juice | 29 6 | 40 7 |
| 057 98 | Fresh fruit (other than citrus, bananas apples grapes figs nuts pears quinces stone fruit, berries, pineapples, dates, avocadoes, mangoes, guavas and mangosteens) | 39 2 | 39 4 |
| 034 1 | Fish, fresh or chilled (excluding fillets) | 34 0 | 36 9 |
| 098 09 | Food preparations, n e s | 19 7 | 36 4 |
| 042 22 | Broken rice | 22 5 | 29 0 |
| 075 26 | Ginger (excluding ginger preserved in sugar or conserved in syrup) | 26 2 | 27 0 |
| 054 59 | Vegetables, fresh or chilled (other than potatoes, tomatoes, onions shallots garlic, leeks and other alliaceous vegetables) | 16 0 | 25 5 |
| 034 4 | Fish fillets frozen | 10 4 | 21 6 |
| 048 3 | Macaroni, spaghetti and similar products | 12 5 | 20 3 |
| 098 04 | Sauces, mixed condiments and mixed seasonings | 15 6 | 20 0 |
| 058 61 | Fruit preserved by freezing, no sugar added | 11 3 | 16 6 |
| 054 61 | Vegetables preserved by freezing | 3 2 | 10 6 |
| 081 19 | Products of vegetable origin of a kind used for animal feed, n e s | 6 2 | 10 5 |
| 081 42 | Flours and meals of fish, crustaceans and molluscs, unfit for human consumption | 11 5 | 9 3 |
| 054 51 | Onions, shallots, garlic, leeks and other alliaceous vegetables, fresh or chilled | 2 9 | 8 4 |
| 042 12 | Rice, husked but not further prepared | 28 8 | 8 2 |
| 075 1 | Pepper of the genus Piper , pimento of the genus Capsicum or of the genus Pimenta | 5 4 | 7 5 |
| 034 3 | Fish, fillets, fresh or chilled | 11 3 | 0 6 |

Source COMTRADE Data Base of the United Nations Statistical Office
a/ Based on import figures
b/ OECD countries (excluding Turkey) and Cyprus, Ecuador Hong Kong, Indonesia, Israel, Korea, Rep of, Morocco Panama, Singapore, Trinidad and Tobago and Tunisia

Table 7 Main selected food products exported by Indonesia a/ into 34 major markets b/ (in US$ million)

| | Product | 1988 | 1989 |
|---|---|---|---|
| 036 0 | Crustaceans and molluscs, fresh, chilled, frozen salted, in brine or dried, crustaceans, in shell, simply boiled in water | 508 1 | 578 4 |
| 054 81 | Manioc, arrowroot, salep, Jerusalem artichokes, sweet potatoes and other similar roots and tubers, fresh or dried, sago pith | 116 1 | 106 0 |
| 075 1 | Pepper of the genus 'Piper", pimento of the genus Capsicum or of the genus "Pimenta" | 129 7 | 97 5 |
| 034 1 | Fish, fresh or chilled (excluding fillets) | 25 5 | 55 5 |
| 081 37 | Oilcake and other residues (except dregs), resulting from the extraction of coconut (copra) | 62 9 | 52 2 |
| 075 24 | Nutmeg, mace and cardamoms | 44 9 | 43 5 |
| 034 2 | Fish, frozen (excluding fillets) | 32 6 | 42 1 |
| 037.1 | Fish, prepared or preserved, n e s (including caviar and caviar substitutes) | 19 7 | 41 6 |
| 075 22 | Cinnamon and cinnamon tree flowers | 25 8 | 38 1 |
| 011 89 | Meat and edible meat offals, fresh, chilled or frozen, other than of sheep and goats, swine, poultry, horses, asses, mules and hinnies | 28 2 | 36 6 |
| 058 99 | Fruits and nuts, prepared or preserved, n e s | 13 3 | 23 6 |
| 081 38 | Oilcake and other residues (except dregs), resulting from the extraction of palm nuts and kernels | 18 8 | 23 0 |
| 098 08 | Edible products of animal origin, n e s | 16 5 | 20 3 |
| 037 2 | Crustaceans and molluscs, prepared or preserved n e s | 14 4 | 16 7 |
| 075 21 | Vanilla | 11 1 | 16 5 |
| 035 03 | Fish dried, salted or in brine (other than cod) | 19 1 | 13 4 |
| 072 32 | Cocoa butter (fat or oil) | 5 9 | 10 6 |
| 081 19 | Products of vegetable origin of a kind used for animal food n e s | 5 3 | 5 8 |
| 081 39 | Oilcake and other residues (except dregs), resulting from the extraction of vegetable oils other than soya beans, groundnuts, cotton seeds, linseed, sunflower seeds, rape or colza seeds, coconut (copra), and palm nuts and kernels | 4 8 | 4 3 |
| 034 4 | Fish fillets, frozen | 3 7 | 4 2 |
| 057 73 | Cashew nuts, fresh or dried, shelled or not | 7 1 | 3 7 |
| 098 04 | Sauces, mixed condiments and mixed seasonings | 3 4 | 3 4 |
| 044 0 | Maize (corn), unmilled | 1 6 | 2 9 |

Source COMTRADE Data Base of the United Nations Statistical Office
a/ Based on import figures
b/ OECD countries (excluding Turkey) and Cyprus Ecuador, Hong Kong Indonesia, Israel, Korea, Rep of, Morocco, Panama, Singapore, Trinidad and Tobago and Tunisia

Table 8 Intra trade in food products within selected Asian countries in 1988 (in US$ million)

| Importer<br>From | Malaysia | Indonesia | Thailand | Philippines | Singapore | China | India | Pakistan | Total 8 countries |
|---|---|---|---|---|---|---|---|---|---|
| WORLD | 1 577 8 | 804 2 | 1 042 4 | 803 4 | 2 391 6 | 3 578 5 | 1 028 2 | 499 2 | 11 725 7 |
| Selected Asian countries total of which | 617 4 | 236 6 | 214 0 | 156 0 | 1 176 8 | 373 5 | 218 6 | 108 3 | 3 101 7 |
| Malaysia | | 6 6 | 10 8 | 6 2 | 603 0 | 14 7 | 0 1 | 4 7 | 646 5 |
| Indonesia | 50 9 | | 33 6 | 2 8 | | 15 1 | 1 3 | 23 1 | 127 2 |
| Thailand | 273 6 | 48 6 | | 17 9 | 206 7 | 305 9 | 159 2 | 13 0 | 1 025 2 |
| Philippines | 2 4 | 0 9 | 2 8 | | 21 6 | 16 2 | 0 1 | 5 1 | 49 4 |
| Singapore | 36 5 | 13 3 | 46 8 | 21 1 | | 9 9 | 5 5 | 6 2 | 139 7 |
| China | 188 0 | 166 8 | 118 4 | 99 1 | 288 6 | | 28 6 | 15 9 | 905 6 |
| India | 62 3 | 0 1 | 0 6 | 7 6 | 42 6 | 0 2 | | 3 3 | 117 0 |
| Pakistan | 2 6 | | 0 6 | | 6 0 | 0 1 | 13 9 | | 23 4 |
| Sri Lanka | 0 8 | | 0 1 | 1 0 | 8 1 | 11 1 | 9 5 | 36 7 | 67 6 |
| Brunei | | | | | | | | | 0 1 |

Source COMTRADE Data Base of the United Nations Statistical Office

– Nil or negligible

Table 9

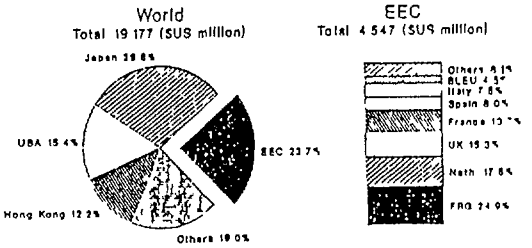
Main food products exported by Thailand, China and India to 8 selected Asian countries a/ in 1988 (in US$ million)

| | THAILAND | Value |
|---|---|---|
| | TOTAL EXPORTS<br>of which | 1 025 2 |
| 042 | Rice | 358 9 |
| 061 | Sugar and honey | 243 3 |
| 054 | Vegetables fresh chilled frozen or simply preserved (including dried leguminous vegetables) roots tubers and other edible vegetable products n e s fresh or dried | 77 4 |
| 044 | Maize (corn) unmilled | 58 0 |
| 034 | Fish fresh (live or dead) chilled or frozen | 48 8 |
| 081 | Feeding stuff for animals (not including unmilled cereals) | 46 0 |
| | CHINA | |
| | TOTAL EXPORTS<br>of which | 905 6 |
| 081 | Feeding stuff for animals (not including unmilled cereals) | 282 8 |
| 222 | Oilseeds and oleaginous fruit, whole or broken of a kind used for the extraction of soft fixed vegetable oils | 174 2 |
| 054 | Vegetables fresh chilled frozen or simply preserved (including dried leguminous vegetables) roots tubers and other edible vegetable products n e s fresh or dried | 100 0 |
| 056 | Vegetables roots and tubers prepared or preserved n e s | 61 2 |
| 057 | Fruit and nuts (not including oil nuts) fresh or dried | 50 1 |
| 075 | Spices | 46 7 |
| | INDIA | |
| | TOTAL EXPORTS<br>of which | 117 0 |
| 054 | Vegetables fresh chilled frozen or simply preserved (including dried leguminous vegetables) roots tubers and other edible vegetable products n e s fresh or dried | 33 7 |
| 011 | Meat and edible meat offals fresh chilled or frozen | 27 4 |
| 081 | Feeding stuff for animals (not including unmilled cereals) | 15 5 |
| 075 | Spices | 9 5 |
| 057 | Fruit and nuts (not including oil nuts) fresh or dried | 7 9 |
| 036 | Crustaceans and molluscs whether in shell or not fresh chilled, frozen salted, in brine or dried, crustaceans in shell simply boiled in water | 4 7 |

Source COMTRADE Data Base of the United Nations Statistical Office

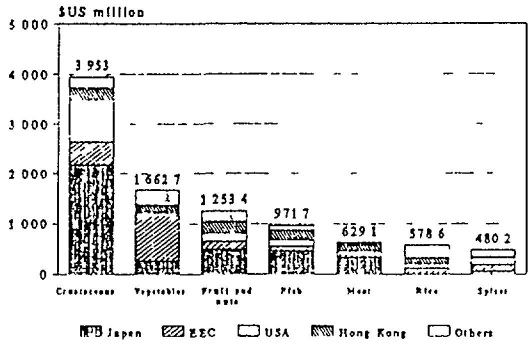
a/ Malaysia, Indonesia, Thailand Philippines Singapore China, India and Pakistan based on import figures

*Chart 1 Supply of food products from selected Asian countries[a], 1990*



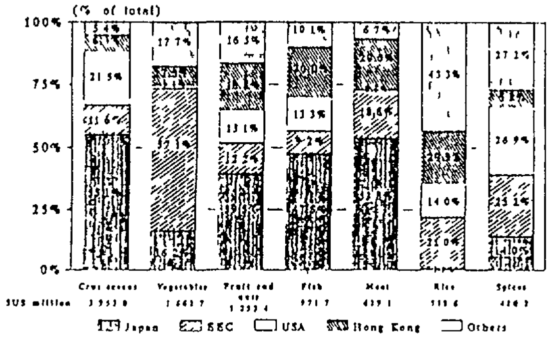

[a] ASEAN countries (Indonesia, Malaysia Philippines Singapore Thailand, Brunei) and China, India, Pakistan and Sri Lanka

*Chart 2A Main destinations of selected food products from Asian countries[a], 1990*



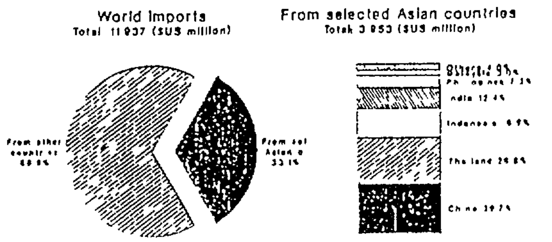

[a] ASEAN countries (Indonesia, Malaysia, Philippines, Singapore Thailand, Brunei) and China India, Pakistan and Sri Lanka

*Chart 2B Main destinations of selected food products from Asian countries[a], 1990*



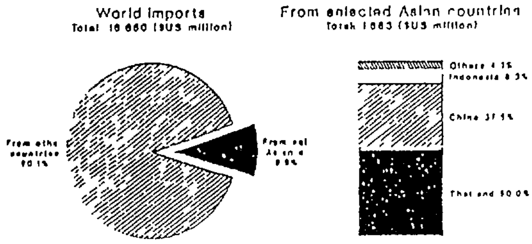

[a] ASEAN countries (Indonesia, Malaysia, Philippines, Singapore Thailand, Brunei) and China, India, Pakistan and Sri Lanka

*Chart 3 Supply of crustaceans and molluscs from selected Asian countries[a], 1990*



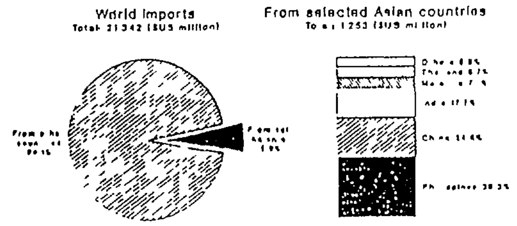

[a] ASEAN countries (Indonesia, Malaysia, Philippines, Singapore, Thailand, Brunei) and China, India, Pakistan and Sri Lanka

*Chart 4 Supply of vegetables, fresh, chilled, frozen, roots, tubers, fresh or dried, from selected Asian countries[a], 1990*



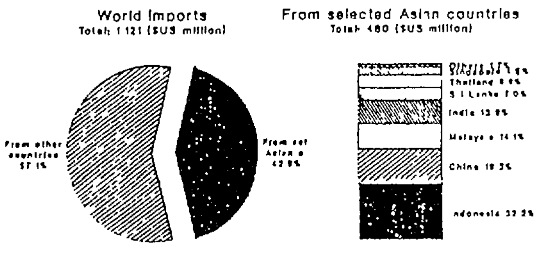

[a] ASEAN countries (Indonesia, Malaysia Philippines Singapore Thailand, Brunei) and China, India Pakistan and Sri Lanka

*Chart 5 Supply of fruit and nuts (excl oil nuts), fresh or dried, from selected Asian countries[a], 1990*




[a] ASEAN countries (Indonesia Malaysia, Philippines Singapore Thailand, Brunei) and China India, Pakistan and Sri Lanka

*Chart 6 Supply of spices from selected Asian countries[a], 1990*




[a] ASEAN countries (Indonesia, Malaysia, Philippines, Singapore Thailand, Brunei) and China India, Pakistan and Sri Lanka

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# OPINION POLLS AND MARKETING TRIALS WITH IRRADIATED FOOD

P. LOAHARANU
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture,
International Atomic Energy Agency, Vienna

**Abstract**

There is a widely held perception among policy makers, food industries and some governments that consumers would be reluctant to accept irradiated food. This opinion has given opposition groups the basis upon which to make the further claim that consumers would reject such food. Indeed, some opinion polls conducted in some Western countries tend to support this claim. It should be noted that these polls were conducted in countries where no irradiated food was available at the retail level. It is clear from these polls that the majority of consumers had never heard of food irradiation much less knew the benefits which they may expect from it. Initially, most consumers appeared to confuse irradiated food with food contaminated with radionuclides (radioactive food). However, when provided with factual information on food irradiation, higher percentages of consumers appeared to be more willing to buy irradiated food.

The situation was quite different when marketing trials of irradiated food were conducted in several countries in the past 5 years, often at the place where non-irradiated food of the same kind were available. These trials conducted in countries such as France, U.S.A., Bangladesh, China, Philippines and Thailand showed that, when consumers had informed choices, they preferred to buy irradiated food, probably on the basis of their higher quality or perceived greater safety. Details of marketing trials of different irradiated food items conducted in the past 5 years will be described.

In recent history, no food processing technology has attracted as much activist and media attention, public debate and political consideration as food irradiation. This controversy has led to a misconception among policy makers, food industries and some governments that consumers would be reluctant to accept irradiated food. It has also given opposition groups to food irradiation, the basis upon which to make the further claims that consumers would reject such food.

Consumers' opinions on irradiated food may be measured by either consumer attitude surveys or consumer response to irradiated food available in the market. This paper attempts to compare results of these two types of studies carried out in the *past several years.*

## Opinion polls

Several nation-wide polls were conducted at the peak of public debates on food irradiation in Canada, United Kingdom and the United States of America when these countries were in the process of introducing regulations on food irradiation in the mid- and late 1980s. Consumers' attitudes to irradiated food may have been influenced by views expressed through the media, whether for or against the use of the technology. During the debates, a number of self-appointed opposition groups emerged from the "middle-of-nowhere" and their views attracted wide coverage by the media. These groups, most of whom had no technical background, or were scientists specializing in disciplines unrelated to food irradiation, often claimed that they represented the consumer-at-large. Their tactics ranged from spreading negative propaganda against the technology to lobbying members of congresses/ *parliaments, issuing threats to food* companies that expressed an interest in using food irradiation, to picketing retail-food stores which conducted market trials on irradiated food, or wished to do so, etc. The following are the summarized results of opinion pools conducted in:

(i) Canada

In March 1984, Canadian Gallop Poll conducted marketability testing of irradiated fish and seafood. Three focus group discussions were conducted with six groups of consumers. In the second phase, 501 consumer interviews in Ontario and 493 interviews in Quebec were conducted. Positive intent to purchase irradiated foods outweighed negative by 3:1. Furthermore, eight in ten correspondents considered irradiation to be a positive idea for consumers (Canadian Gallop Poll Ltd., 1984).

Since that time, negative media reports may have affected consumer attitudes. A later study concluded that in spite of negative press accounts, there is very little familiarity with irradiation among consumers; most consumers did not have an opinion. The study of the grocery buying habits of 1,350 households found that less than one-quarter consider themselves to be familiar with irradiation, the remaining consumers are aware of irradiation but do not consider themselves familiar with it. Twenty per cent have never heard of it. Almost half had no opinion on the process, 20% were neutral, 25% had unfavourable impressions and 10% were positive (GPMC, 1988). In another study conducted in 1990, 27% of Canadians indicated they were very interested in irradiation as a way of preserving food; 58% were fairly interested. When they were asked to rank subjects noted as interesting to them, irradiation was placed 15th out of 21 interests (GPMC, 1990).

(ii) United Kingdom

In mid-1986, the Consumers' Association's magazine Which? (Anonymous, 1986) surveyed 2,000 members of the general public and reported that "many people in our survey were confused about the effects of food irradiation - more than half incorrectly identified six or more true or false statements out of 13". It should be noted that a lot of media attention was given to the major nuclear accident at Chernobyl which coincided with the publication of the United Kingdom Advisory Committee on Irradiated and Novel Foods in April 1986, which reported on the safety and wholesomeness of irradiated food. Erroneous links between the two were made by the media and taken up by the general public. In that survey, more than half of the people said that they would not buy foods that had been irradiated, even if they were cheaper.

The County Trading Standards Department conducted a survey on public perception of food irradiation and its implications for food processing and marketing in late 1987 and published the outcome in its Information Note in July 1988 (Anonymous, 1988). A sample of 1,640 citizens were interviewed during the second half of 1987. They were given a short description of food irradiation as:

> "There has recently been discussion on television and in the press about a process called food irradiation. This process uses radiation to preserve food, killing bacteria and making it keep longer. It does not make food radioactive. At the moment, it is illegal to sell irradiated food in this country but the Government is considering making it legal".

They were then asked "If you had a choice, would you prefer to buy food which was irradiated, food which was not irradiated or would you not be bothered one way or the other?". It was not surprising to learn the outcome which showed that:

3% would prefer irradiated food;
61% would prefer non-irradiated food;
28% would not bother
8% don't know

In June 1989, the Consumers' Association conducted another survey to assess consumer understanding and attitudes towards food irradiation (Anonymous, 1990). The survey aimed to discover whether or not people are generally more knowledgeable about food irradiation than they were three years ago and whether or not their attitudes have changed towards the subject. In-home interviews were made with around 2,000 respondents in June 1989. They were informed that 'Food irradiation is a means of preservation - in other words, it extends the shelf-life of food. It exposes food to what is called "Ionising Radiation". At present, food irradiation is not generally permitted in this country but if it were to be introduced on the basis of recent recommendations, it would not make food radioactive'.

The following are excerpts from the summary of the report of Consumers' Association:

- Over half the population had heard of, or read about, food irradiation (a significant increase over 1986 survey).
- Knowledge about food irradiation remained incomplete and uncertain.
- About half felt that the likely effects of food irradiation would be bad rather than good.
- Around half felt that food irradiation should not be permitted in the United Kingdom.
- Given the choice between irradiated food, food preserved with conventional preservatives, or untreated food, four out of five would prefer the conventional preservatives or untreated food.

All these surveys stressed the preference of consumers on labelling of irradiated food in the United Kingdom.

(iii) United States of America

In a survey of 1,000 consumers conducted for the Department of Energy and the National Pork Producers Council in February 1984, 55% of respondents expressed a major concern about chemical sprays used on fruits and vegetables. About 38% of respondents expressed the same level of concern about irradiation (Morrison and Roberts, 1985).

In a consumer attitude survey done by Opinion Research for the US Food Marketing Institute in 1987, 75% of respondents found that pesticides and herbicides posed a major threat to the nation's food supply; 43% considered food irradiation to be a serious hazard; 29% thought food irradiation was somewhat dangerous, 20% were not sure, and 8% believed food irradiation was safe (CRA Info, June, 1987).

Another study re-inforced the message that irradiated food should be promoted, not the process of food irradiation. A private research firm, commissioned by the US National Marine Fisheries Service, found that consumers can be divided into rejectors (5% to 10%), acceptors (25% to 30%), and undecideds (55% to 60%). The percentages represent consumers' acceptance, based on a description of the technique and how radiation affects foods. When the pollsters described the benefits of irradiation to another group, without delving into the technology, the acceptor score shot up to 72% and the rejector tally stayed at 6%. Sell the product, the survey concluded, not the process (Steyer, 1986).

In 1987, a study of consumer acceptance of irradiated food was conducted by Washington State University. The focus group method was used and questionnaires were administered before and after group discussions to assess the level of concern. The homemakers in the study were reported to have preferred irradiation over chemical treatments, they saw advantages for fish, berries, bananas and tomatoes. About 30% fully trusted FDA's position on food irradiation. The consumers were reported to be willing to be open minded about food irradiation (Dickrell and McCracken, 1987).

A similar effect was seen in a study of urban, suburban and rural food buyers in Missouri households by Central Missouri State University. A one-paragraph statement outlining the benefits of irradiation and giving the approval of several health organizations resulted in a 48% stated willingness to buy irradiated produce that was priced US$.03 higher per pound than unirradiated produce. Only 46% of the households said they would buy the unirradiated produce at a $.03 lower price per pound. At the $.03 per pound higher price, 66% of the highest income earning households stated their preference for irradiated produce (Terry and Tabor, 1988).

A national US mail survey was conducted by the Center for Consumer Sciences, University of California, Davis, in the Spring of 1988, of consumer awareness and concern about irradiated foods and the influence of labelling information on willingness to purchase irradiated foods (Schutz et al. 1989). The survey also questioned attitudes towards pesticides, additives, labelling and organic foods. After a short description of the process, about 60% of respondents indicated they had heard of irradiation; 37% had not and 3% didn't know. When asked for their reaction, if irradiation was used on food, about 25% indicated a major concern, 21% indicated a minor concern, about 34% were undecided and about 21% indicated no concern. When given a short statement on the reason for and benefit of irradiation, 58% indicated they would prefer to buy irradiated poultry (18% preferred unirradiated); 57% preferred irradiated pork (19% preferred unirradiated); 43% preferred irradiated fruit (33% preferred unirradiated fruit), 58% preferred irradiated spices (3% preferred gas-treated spices). The authors indicated their results were consistent with the now considerable literature on consumer acceptance of irradiated food.

**Marketing trials**

The consumer can objectively evaluate and make the most of his/her choice only if he/she has the possibility of selecting and purchasing (Moog, 1989). A number of marketing trials on several irradiated food items, with clear labels indicating the treatment, were carried out in the past several years to evaluate consumer acceptance of irradiated food. The summary of these trials are included in Table 1. The details of marketing trials in the following countries are highlighted:

(i) Argentina

Two marketing trials of irradiated onions were conducted under the joint effort of Universidad Nacional del Sur, a wholesale cooperation (FOCO, S.A.) and a supermarket (Cooperative Oprera Limitada) in August and October 1986 (Urioste et al. 1990). A total of seven metric tonnes of irradiated onions were put on sale in the produce section. The products were packed in one or two kg. netting bags with a label indicating irradiation treatment. A poster explaining the benefits of irradiation and that the trials were authorized by the Ministry of Health, was displayed at the point of sale. A questionnaire was handed out to the customers who bought irradiated onions for opinion assessment after the consumers had used the product. Irradiated onions were sold at a rate of one tonne per day.

A week after the sale took place, an opinion survey of 200 consumers was conducted by phone. In both trials, the most important reason for purchasing was the treatment, especially in October trial when other onions available in the market were of inferior quality. The majority of consumers had a positive repurchase intent, i.e. the percentages of those who said they would buy irradiated onions again were 97.8% in August and 87.7% in October.

(ii) China

The market testing and consumer acceptability studies of 110 tonnes of irradiated seasonings and meat products containing irradiated seasonings were carried out in Chengdu, Lanzhou, Jaiyuan, Xian, Zhengzhou from August 1990 to April 1991. Information desks were established in stores selling the irradiated products. Statistical data on 2,045 consumers investigated showed that 67% of consumers had heard of food irradiation and around 70% of families were willing to buy irradiated foods. In general, consumers encouraged practical application of food irradiation processing in China (Chen, 1991).

Consumer in-store response to irradiated apples was carried out in Shanghai from February to May 1991. The results of 634 consumer responses showed that nearly 60% had heard of food irradiation; only 33% of the buyers understood food irradiation; 30% of buyers had tasted irradiated food; 43% of buyers had misgivings regarding irradiated food before the trial, but after receiving factual information, the percentage of buyers' "misgivings" decreased to 11%. After tasting irradiated apples, 92% of buyers said that they appreciated the qualities, colour, sweet smell, and flavour of irradiated apples. Ninety-three per cent of the consumers stated that they were in favour of developing irradiation preservation of foods; and 90% of consumers said that they would again buy irradiated food (Xu, 1991).

(iii) France

Two metric tonnes in 1987 and five metric tonnes in 1988 of irradiated strawberries (2 kGy) were put on sale by a supermarket chain in Lyon, France. The product was labelled by the "RADURA" logo plus a statement of "ionization" and sold at slightly higher cost than non-irradiated strawberries. The consumers preferred to buy more irradiated strawberries in view of their better quality (Moog, 1988).

(iv) Poland

Four tonnes of irradiated onions and three tonnes of irradiated potatoes were put on market trials in Poznan. They had been stored in uncontrolled conditions for nine months previous to the trials. Responding to a survey, about 97% of consumers gave a positive opinion of the products and said they would buy irradiated onions and potatoes in the future (Fiszer, 1988).

(v) Thailand

A popular fermented pork sausage (Nham) is normally consumed in Thailand "raw" - i.e. without cooking or any heat treatment. This product is often contaminated by *Salmonella* and occasionally by *Trichinella spiralis*. Irradiated Nham (2.0 kGy minimum), with labelling as required by the Thai Food and Drug Administration, has been put on sale side-by-side with non-irradiated products in a few supermarkets in Bangkok since 1986. Results of a consumer survey conducted in 1986, with a total of 138 completed questionnaires, showed that 34.1% of the surveyed consumers bought irradiated Nham out of curiosity and 65.9% bought it on their belief of its safety from *Salmonella* and *Trichinella*. Also, 94.9% of the consumers indicated that they will buy irradiated Nham again. During three months when the survey was conducted in 1986, irradiated Nham outsold non-irradiated product by a ratio of 10:1 (Prachasitthisak, 1989).

(vi) United States of America

1. Irradiated Mangoes. Two metric tonnes (100 cases) of Puerto Rican mangoes were irradiated up to a dose of 1 kGy in Puerto Rico and flown to Miami for the test in September 1986. Irradiated mangoes were labelled with a large sign around the bins and were sold alongside with non-irradiated mangoes in a Farmers Market in the North Miami beach. Irradiated mangoes were sold out within a few days with no apparent reluctance from the buyer (Giddings, 1986).

2. Irradiated Papaya. A shipment of Hawaiian papaya was flown to Los Angeles in March 1987 for irradiation at a dose of 0.41-0.51 kGy to satisfy quarantine regulations. They were put on sale, fully labelled according to the requirement of FDA, alongside with unirradiated but hot-water dipped papaya for the same purpose, in two supermarkets in Anaheim and Irvine, California. More than 200 consumer questionnaires were completed during taste testing of the two lots of papaya. At the end of the eight-hour market test, 150 lb of irradiated papaya and 13 lb of hot-water dipped papaya were sold, representing a ratio of 11:1 in favour of irradiated papaya. Sixty-six per cent of the participating consumers at Anaheim and 80% at the Irvine supermarkets stated that they would buy irradiated papaya again (Bruhn and Noell, 1987).

Positive results on other market testings of a number of irradiated food items including potatoes, onions, garlic, dried fish, apple, etc., were obtained in Bangladesh, Hungary, Philippines, and the United States of America in the past five years. In all cases, the most significant factor which influences the acceptance of irradiated products appears to be their superior quality. It is also important to note that in none of these tests, actually carried out in market places, there is an evidence to indicate that informed consumers will not accept irradiated foods. A summary of market testings of irradiated foods including consumer attitude research has recently been compiled (Marcotte, 1988).

The results of market trials mentioned above clearly domenstrated that whenever consumer had a choice, they not only would be willing to buy irradiated food, but often bought them overwhelmingly over their non-irradiated food counterparts. From these trials, it appears that consumers already recognized the benefit of irradiation in terms of availability during off-season marketing, quality in terms of appearance, colour and taste. The benefit of irradiation of fruits such as papaya and strawberries is rather unique as it can be used for treating fruits which are more mature in ripeness. Thus, in certain cases, consumers are already aware of the benefit of irradiation in making more natural riped fruits which are better flavour, available to them.

Table 1 Market trials of irradiated foods (1984-1990)

| Country | Irradiated food items | Date of testing | Remarks |
|---|---|---|---|
| Argentina | onion, garlic, garlic powder | 1985-1988 | Consumers positive to irradiated foods 95% like to buy irradiated onions |
| Bangladesh | potato, onion, dried fish, pulses | 1984-1988 | Consumers preferred irradiated foods |
| China, P R | spirit from sweet potato, sausages, apples, potato, hot pepper and products, orange, pears | 1984-1990 | Consumers positive to irradiated products |
| Cuba | potato, onions, garlic | 1988 | Consumers positive to irradiated products |
| France | strawberries | 1987-1988 | Consumers preferred irradiated strawberries in spite of higher price |
| Germany Dem Rep | chicken, spices | 1985-1987 | Consumers positive to irradiated products |
| Indonesia | dried fish | 1986-1988 | Consumers positive to irradiated products |
| Pakistan | potato, onion | 1984-1987 | Consumers positive to irradiated products |
| Philippines | onion, garlic | 1984-1987 | Consumers positive to irradiated products |
| Poland | onion, potato | 1986-1988 | 90-95% of the consumers preferred irradiated foods |
| Thailand | nham (fermented pork sausage), onion, garlic | 1986-1988 | 95% consumers preferred irradiated nham. Consumers positive to irradiated onions and garlic |
| USA | mango, papaya, apple | 1986-1988 | Consumers preferred irradiated mangoes and apples Irradiated papayas sold at a ratio of 11 1 over non-irradiated papaya |
| Yugoslavia | herbal extracts | 1984-1985 | Consumers positive to irradiated products |

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# TECHNICAL BASIS OF REGULATORY CONTROL OF THE IRRADIATION FACILITY AND THE PROCESS

(Session III)

**Chairman**

**P.M. NAIR**
India

# PRINCIPLES OF THE CODEX GENERAL STANDARD FOR IRRADIATED FOODS AND ASSOCIATED CODE OF PRACTICE

L.G. LADOMERY
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture,
International Atomic Energy Agency, Vienna

*Presented by P. Loaharanu*

## Abstract

The Codex Alimentarius Commission, which is the Executive Organ of the Joint FAO/WHO Food Standards Programme, adopted in 1983 a General Standard for Irradiated Foods and a Recommended International Code of Practice for the Operation of Radiation Facilities used for the Treatment of Foods. The Standard takes into account the conclusions of Joint FAO/IAEA/WHO Expert Committees convened to evaluate all available data concerning the effects of irradiation treatment on food, including extensive wholesomeness data and animal tests. The Standard represents a set of principles and requirements for the process and for the irradiated product. It does not go into details concerning the application of food irradiation to individual food products on groups of food products in accordance with good irradiation practice. Such details are covered in a special Codes of Good Irradiation Practice elaborated by the FAO/IAEA/WHO International Consultative Group on Food Irradiation.

The lecture will describe the various provisions of the Codex Standard for Irradiated Foods and the Code and provide explanation of the intent of these provisions, drawing attention to the actual practices followed by Governments in regulating food irradiation.

## Introduction

The Codex Alimentarius Commission, which is the Executive Organ of the Joint FAO/WHO Food Standards Programme, adopted in 1983 a General Standard for Irradiated Foods and a Recommended International Code of Practice for the Operation of Radiation Facilities used for the Treatment of Foods. The Standard takes into account the conclusions of Joint FAO/IAEA/WHO Expert Committees convened to evaluate all available data including extensive wholesomeness data and animal tests. The Standard represents a set of principles and requirements for the process and for the irradiated product. It does not go into details concerning the application of food irradiation to individual food products on groups of food products in accordance with good irradiation practice. Such details are covered in a special Code of Good Irradiation Practice elaborated by the FAO/IAEA/WHO International Consultative Group on Food Irradiation.

## Process-related provisions

Radiation source

In order to ensure that no radioactivity, no matter how transient, should be induced in the food, X-rays and electrons from machine sources are limited to 5 MeV and 10 MeV respectively. In practice, $^{137}Cs$ is seldom used because of its limited availability.

Licensing of facility

The Codex Standard requires that the facility be licensed and registered by a trained personnel of competent national authority. In response to this requirement, the International Consultative Group on Food Irradiation (ICGFI) has decided to set up an "International Inventory of Authorized Food Irradiation Facilities. ICGFI has also developed "Guidelines for Preparing Regulations for the Control of Food Irradiation Facilities" which are intended for the information of

Government.

Process control

The Codex Standard requires facilities to keep adequate records of operations, including quantitative dosimetry and the observance of "good radiation processing practice", as described in general terms in the "Recommended International Code of Practice for the Operation of Irradiation Facilities Used for the Irradiation Treatment of Foods".

The International Consultative Group (ICGFI) mentioned above, has elaborated a set of Codes for "Good Irradiation Practice" covering applications of current interest. These voluntary codes are complementary to the Codex General Standard for Irradiated Foods. Their application is assured by regulatory inspection at the national level and by the self-enforcing nature of most applications of food irradiation processing.

Food irradiation, like other food processing methods, is performed for definite reasons (e.g. food technological, plant quarantine, public health, etc.). Many of these (delaying ripening, reduction of spoilage microorganisms, etc.) are of interest to the trade itself, which ensures that good and effective practices are followed. Other applications such as quarantine control is under the control of the responsible national authorities of the importing countries, usually involving also the authorities of the exporting countries. Applications to improve the hygienic quality and safety of foods (e.g. elimination of parasites and pathogens in food) is a field, where public health authorities have a direct responsibility. This is true of any food, whether irradiated or not.

**Food-related provisions**

Absorbed dose

The Codex General Standard only recommends a single upper limit, i.e. average overall dose absorbed by a food of 10 kGy. It should be noted that this dose limit is not based on technological considerations, but represents the highest dose tested in wholesomeness studies (e.g. in test animals, in chemical and other tests). The limit of 10 kGy is not being suggested to be a mandatory legal maximum limit (NB: use of "should" rather than "shall" in the standard), but as a level up to which the safety and wholesomeness of irradiated food has been conclusively established by the Joint FAO/IAEA Expert Committees on Food Irradiation. This does not necessarily mean that food irradiated above this level is not safe from a point of view of the slight chemical changes induced in the food through the input of electromagnetic energy. In fact, some countries permit the irradiation of certain foods above 10 kGy, e.g. spices and food sterilized by irradiation (for astronauts and hospital diets, including immunodepressed persons) which must receive higher doses.

While the Codex General Standard only specifies a single upper limit as mentioned above, national authorities tend to set statutory (i.e. mandatory) limits reflecting "good irradiation practices" on a food-by-food basis. This is being done in an unharmonized manner with the result that there is lack of agreement between countries on:

(a) which foods should be covered by national limits;

(b) the definition of foods and groups or classes of foods;

(c) the exact meaning of the statutory limit (average, overall average, absolute limit, range, etc.);

(d) the basis for setting limits for absorbed doses; and

(e) the interpretation of compliance of shipments of irradiated food with the legal limits.

In the absence of significant international trade in irradiated food, this lack of harmony is of little practical consequence, but represents a potential barrier to trade if not corrected.

Annex B to the Recommended International Code elaborated by Codex lists foods and average doses purely for illustration of the utility of the process. The list is not intended to be a restrictive list of permitted applications.

Hygienic quality of food

The Codex Standard does not provide for specific microbiological or hygienic requirements for irradiated foods, but requires that irradiated foods should be subject to the same hygiene requirements as non-irradiated foods. However, the Codex standard recognizes that there may be national public health requirements relative to microbiological safety of the food which have to be complied with.

The Codex Standard also requires that the food to be irradiated shall be of "acceptable hygienic condition" and shall be handled before and after irradiation according to good manufacturing practice (GMP). The Standard does not provide details of what is "acceptable hygienic condition".

ICGFI codes of Good Irradiation Practice mentioned above suggest microbiological criteria for foods to be irradiated. The Codex Codes of Good Hygienic Practice provide guidance for the handling of various types of food under good manufacturing practices.

Packaging requirements

The Codex Standard requires that packaging materials be of "suitable quality, acceptable hygienic condition, appropriate for irradiation and be handled before and after irradiation in accordance with GMP".

The Standard does not include any specific details or requirements concerning packaging materials. ICGFI Secretariat is collecting information on lists of packaging materials authorized nationally for the irradiation of foods.

Justification for the radiation treatment

The Codex Standard states that "food irradiation is justified only when it fulfils a technological need or serves a food hygiene purpose and should not be used as a substitute for GMP".

The requirement implies that a judgement has to be made in individual applications of radiation treatment on the following:

(a) technological need;
(b) food hygienic purpose;
(c) good manufacturing practice.

Under the aegis of ICGFI, two technical compilations have been prepared providing full details on the above three and other aspects for spices and poultry irradiation. These documents, which are complementary to the Codex Standard, provide governments and the interested industry with full information on the basis of which application of irradiation may be authorized.

Re-irradiation

The Codex Standard permits the re-irradiation of low moisture foods treated at low levels e.g. disinfestation Codex Standard also defines those situations where a second application (total within 10 kGy) is not considered to be "re-irradiation", e.g. where:

(a) food prepared from materials which have been irradiated at low dose levels (e.g. about 1 kGy) is irradiated for another purpose; (e.g. say decontamination of raw meat products containing irradiated cereals).

(b) food containing less than 5% of irradiated ingredients is irradiated (e.g. say decontamination of raw meat product containing irradiated spices).

(c) full radiation dose is achieved in more than one instalment.

NB: At this stage, most countries have simply forbidden re-irradiation.

Labelling

See paper "Labelling of Irradiated Foods (including Shipping Documents) and other Provisions relating to the Product moving into Trade."

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5. Code of Good Irradiation Practice for the Control of Pathogens and Other Microflora in Spices, Herbs and Other Vegetable Seasonings (ICGFI Document No. 5).

6. Code of Good Irradiation Practice for Shelf-life Extension of Bananas, Mangoes and Papayas (ICGFI Document No. 6).

7. Code of Good Irradiation Practice for Insect Disinfestation of Fresh Fruits (as a quarantine treatment) (ICGFI Document No. 7).

8. Code of Good Irradiation Practice for Sprout Inhibition of Bulb and Tuber Crops (ICGFI Document No. 8).

9. Code of Good Irradiation Practice for Insect Disinfestation of Dried Fish and Salted and Dried Fish (ICGFI Document No. 9).

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# CONTROL OF FOOD IRRADIATION FACILITIES AND GOOD IRRADIATION PRACTICES

P. POTHISIRI
Ministry of Public Health,
Bangkok, Thailand

## Abstract

Expansion of irradiation facilities employing commercial scale processes is evident in several countries. The list compiled by the Food Preservation Section of the Joint FAO/IAEA Division, Vienna (April 1988) showed that 34 countries have approved the use of irradiation process for more than 40 food commodities. In Asia and the Pacific Region, the main commercial application of irradiation process is still the sterilization of medical devices but applications to food processing are on the rise. To ensure the safety of irradiated foods, laws and regulations have to be promulgated to govern the facilities, the operations and the products. In most cases, there may be more than one governmental agency involved in regulatory control. The control activities include licensing/registration of a food irradiation premises as a food processing plant, registration of irradiated food in accordance with prescribed standards and regulating labelling practice as well as regularly conducting a comprehensive inspection of the facilities.

The quality control programme must cover all aspects of treatment, handling, and distribution. It is emphasized that, as with all food technologies, effective quality control systems need to be installed and adequately monitored at critical control points at the irradiation facility. Foods should be handled, stored, and transported according to GMP before, during, and after irradiation. Only foods meeting microbiological criteria and other quality standards should be accepted for irradiation. Besides, good irradiation practice (GIP) is also a fundamental principle of practice required specifically for food irradiation. With this recognition, the International Consultative Group on Food Irradiation (ICGFI) has elaborated a set of eight codes of GIP. The quality control system would also include proper packaging suitable for the product. Additional use of a logo to identify irradiated food should be permitted and may even become recognized as a symbol of quality.

Food irradiation offers an opportunity for health and economic benefits, including the enhancement of international trade in food and reductions in post-harvest losses and in foodborne diseases. At the same time, the food irradiation process should not be seen as an alternative to acceptable hygienic practices nor should it be utilized to mask serious bacterial contamination and mishandling of food. To achieve strict adherence to the highest hygienic standards, food irradiation facilities should be subject to rigorous control measures.

Governments play an important role in the control of irradiation facilities and processes. To maximize their effectiveness, governments must ensure that the irradiation process is regulated and that these regulations are effectively monitored and enforced. Enforcement of the pertinent regulations in order to assure food safety and wholesomeness as well as the proper operation and maintenance of the irradiator should take into account a score of different control activities, including licensing and registration of irradiation sources and facilities, licensing of food processor and registration of irradiated food, inspection and labelling control.

Certain essential strategies, therefore, are needed to ensure successful control implementation:

(1) As more than one government agency or authority may be involved, it is essential that an integral government policy clearly identifies the division of responsibilities,

authorities and cooperation among the agencies concerned. In the case of Thailand, the agency responsible for applications of nuclear energy, the Office of Atomic Energy for Peace (OAEP), is entrusted with a duty of licensing and registration of irradiation facilities as well as regulating radiation dosimetry. Concurrently, the Food and Drug Administration of the Ministry of Public Health, is assigned to look after the food irradiation process as part of its food control programme. The control activities include both licensing/registration of the food irradiation premise as a food processing plant and also registration of irradiated foods in accordance with prescribed standards and labelling requirements. Inspection of food irradiation facilities is carried out by joint inspection team. Hence, close cooperation between these two agencies is required, particularly on technical matters.

(2) A practical but comprehensive programme for training of personnel involved in regulatory control programme is required.

(3) Research and development activities are also indispensable, especially in developing an appropriate (GIP) irradiation treatment for any new food item. In Thailand, the Agriculture Department acts as a core unit and also a coordinator, working in close liaison with a number of universities, research institutes and food industries to optimize research and development.

**Process control**

According to the Codex General Standard for Irradiated Foods, irradiation facilities must be designed so that they meet the requirements of safety, efficacy and good hygienic practices of food processing. Food irradiation facilities should operate under a quality control programme endorsed by food control officials.

The quality control programme must be compatible with other control systems so as to ensure general food safety. The system developed by the plant should include evaluation of the incoming product, preparation of the product for irradiation, pre-treatment of food such as cooling, chilling and freezing which, wherever necessary, should be carried out in an effective manner. Whenever required, food should be pre-packed in appropriate packaging material, and the radiation dose absorbed by the product (i.e. the outgoing product) should be controlled before distribution. The control system should be based on the hazard analysis and critical control point (HACCP) system, a concept that identifies points in the operation where food safety and quality are determined and then monitors those aspects to ensure that the operation is under control. The HACCP system for an irradiation plant should include incoming product control, pre-processing control, processing control and post-processing control.

Good manufacturing practice (GMP) for food irradiation requires that a food is exposed to absorbed dose that achieves a successfully preserved product. The maximum absorbed dose must comply with the tolerable dose for the product or any legal limit values. The range between minimum and maximum absorbed dose should not be unnecessarily wide.

Dosimetry is an important aspect of radiation control. The purpose of dosimetry is to measure dose distribution, set product parameters, control compliance with dose limits, and verify control of the process. To establish correct dose distribution throughout the products, dosimeters should be distributed in suitable numbers and placed at all important points. Proper records of dosimetric measurements, along with other information such as the doses applied, the nature of the product, the source of radiation, the identifying mark and the date of treatment, are helpful in the process control. This dosimetry information enables qualified plant personnel to monitor the process and to regulate the radiation dose. The operators can determine the most efficient arrangement of the product on the racks or conveyor belts and control other factors that influence the dose of radiation absorbed by the food. As it is not easy to distinguish irradiated food from non-irradiated food by inspection or any other means, it is necessary to depend on process controls at the radiation facility. Simple radiation indicators, which can help in identifying the food treated with radiation at the time of operation, can be applied either on the product unit pack or on the carton.

Temperature conditions during the irradiation process should be maintained in accordance with GMP to avoid possible changes in the organoleptic characteristics of the food and to avoid the growth of microorganisms.

Documentation is another important aspect of food irradiation control. Documentation that is kept at the plant and is accessible to control officials should include commissioning information, dose mapping for individual products, source position data, product loading patterns, conveyor operation, number and duration of processing interruptions, start and stop times of processing and irradiation time.

**Good Irradiation Practices**

Good manufacturing practice (GMP) for food processes is always necessary and must be followed at any stage in the production, storage, handling or processing of food. Food intended for treatment by irradiation should be of a quality acceptable for GMP. Good irradiation practice (GIP) is also a fundamental principle of practice required specifically for food irradiation in order to ensure process control for different types or groups of foods.

It is desirable, therefore, to develop codes of good irradiation practices (GIP) also based on the principle of the Codex General Standard for Irradiated Foods, for the industry/irradiation facility to observe as their guidance for quality assurance. Such codes need not have the force of a regulation as their content need not be subject to government control.

Recognizing the importance of codes of GIP, the International Consultative Group on Food Irradiation (ICGFI) has elaborated under its procedures, including comments by governments, a set of eight codes of GIP as follows:

(1) Code of Good Irradiation Practice for Insect Disinfestation of Cereal Grains (ICGFI Document No. 3).

(2) Code of Good Irradiation Practice for Pre-packaged Meat and Poultry (to control pathogens and/or extend shelf-life) (ICGFI Document No. 4).

(3) Code of Good Irradiation Practice for the Control of Pathogens and Other Microflora in Spices, Herbs and Other Vegetable Seasonings (ICGFI Document No. 5).

(4) Code of Good Irradiation Practice for Shelf-Life Extension of Bananas, Mangoes and Papayas (ICGFI Document No. 6).

(5) Code of Good Irradiation Practice for Insect Disinfestation of Fresh Fruits (as a quarantine treatment) (ICGFI Document No. 7).

(6) Code of Good Irradiation Practice for Sprout Inhibition of Bulb and Tuber Crops (ICGFI Document No. 8).

(7) Code of Good Irradiation Practice for Insect Disinfestation of Dried Fish and Salted and Dried Fish (ICGFI Document No. 9).

(8) Code of Good Irradiation Practice for the Control of Microflora in Fish, Frog Legs and Shrimps (ICGFI Document No. 10).

These Codes have been finalized and ready to be published by ICGFI. They will be distributed to industry/irradiation facilities which are being used for food processing as well as national authorities responsible for food control.

**Radiation protection measures**

Radiation protection activities are designed and regulated to prevent accidental irradiation of plant workers and the release of radiation into the environment. Although each of the countries that has approved food irradiation has its own legislative approach to ensure that such accidents do not occur, they all follow the broad pattern summarized below:

(i) Licensing

In addition to being licensed as food processing establishments, food irradiation plants should be licensed by the government agency responsible for the regulation of irradiation applications and installations. Such a licence should be granted only after a thorough investigation has established, among many other things, that the site for the plant is safe and appropriate, that the design and construction meet applicable standards, that its operators are fully trained to carry out their tasks and that operating plans and procedures give all necessary attention to the requirements of radiation safety. The terms and conditions of licensing are likely to change as new information and experience become available. Licensed facilities should be obliged to comply with such changes as a condition of continued approval.

(ii) Operating controls

A plant that has been licensed to irradiate food should be subject to regular quality control and quality assurance procedures to verify that the plant is operating according to the licence agreement. These performance checks should examine the quality of the products being irradiated, ensure that the proper dose of radiation is being delivered for the intended effect, and verify that irradiation procedures are being followed scrupulously. The irradiation process must incorporate appropriate safety arrangements. The source (isotope or electron beam) must be placed within a biological shield - a building of concrete which completely surrounds the irradiation unit with walls of a thickness such that there is no possibility of radiation exposure outside the shield. The isotope radiation source, when not in use, should be stored in a deep tank of water or a dry storage container which absorbs the radiation. A series of fail-safe procedures is needed to ensure that the isotope cannot be raised into the working position or the electron beam switched on if any person is in a position to be exposed to any radiation.

**Packaging and labelling**

The quality control system would also include proper packaging suitable for the product and appropriate temperature control during storage and handling. Extension of shelf life of foods by irradiation alone would probably not be practical if the irradiated products are not handled with the proper processing care. For example, irradiated cereals without packaging could become infested by insects or contaminated by microorganisms. Therefore, after treatment the products should be packed and stored in such a way that reinfestation or recontamination is prevented.

Labelling of irradiated products is also important, since it not only informs consumers that the product has been irradiated, but also indicates the purpose for which treatment was given, for example, to inhibit sprouting of vegetables, to delay maturation of fruit, to ensure the hygienic quality of meat and fish, etc. Additional use of a logo to identify irradiated food should be permitted and may even become recognized as a symbol of quality.

**Training of plant personnel and inspectors**

Personnel training must form an integral part of all food irradiation control procedures. Such training should place emphasis on the use of irradiation to ensure hygienic quality, correct use of irradiation to reduce post-harvest food losses, and irradiation as a quarantine treatment for the proper control of food irradiation with special emphasis on GMP.

The trained technical staff of an irradiation plant who have to enter the irradiation room for maintenance or repair, and who, theoretically, could be exposed to radiation, should carry dosimeters with them. Regular evaluation of the dosimeter records and medical surveillance will ensure that these workers never receive an exposure above the maximum permissible level. Internationally recognized guidelines for radiation protection have been established by the International Committee for Radiological Protection.

In addition to internal monitoring, each food irradiation plant should be subject to both regularly scheduled and unannounced inspections by government personnel to make sure that they comply with the terms of their licences and with applicable regulations. Government regulatory agencies can often provide technical guidance and training to help these plants maintain high standards and apply new technical and scientific information. As well, training programmes for food control officials should emphasize the correct inspection procedures required for food irradiation processing and control of irradiated food in trade.

**Inspection**

Since irradiation leaves little identifiable trace of the process in foods, the only way to effectively control it is to shift the moment of control one phase back. Inspection has to be performed through a system of documentation, allowing each batch of irradiated food to be identified with the irradiation facility and with the treatment given, and through a system of labelling or other appropriate method of identification of the food itself. Inspection of the facility should be carried out by an authorized agency, recognized by the Ministry of Health.

The facility should be inspected before locating the first source, again directly thereafter and regularly during operation. Inspection during operation requires that the following be examined:

(a) Checking that the operation meets all the requirements laid down in the licence and that the plant is well maintained.

(b) Reviewing the logs and records, the results of various tests, maintenance and monitoring programmes.

(c) Conducting periodic audits to ensure that the quality assurance programme is being properly carried out.

(d) Checking that the recommendations made after a previous inspection have been taken into account.

(1) Dose distribution

Establishing the treatment implies showing the ability to meet the minimum effective dose of the process and observing any maximum dose for reasons of product quality tolerance or legal limits. This is usually done by labour and time consuming measurements of depth dose distributions. From the knowledge gained, a reference point can be assigned to a package or treatment unit for which measured dose values can be monitored to ensure the quality of radiation processing.

(2) Process parameters

Direct monitoring of a suitable process parameter is a substitute for comprehensive and permanent radiation dosimetry during the course of a given treatment. It also serves to monitor dose distributions and the adjustments necessary due to unavoidable fluctuations of the process. Documentation of all relevant process parameters monitored also serves to prove that the correct treatment has been carried out on a product, settle disputes on a treatment with customers, and fulfil the obligations and requirements laid down by the responsible authorities.

(3) Calibrating dosimeters and process parameters

All instruments used for radiation processing and for monitoring process parameters need calibration against acceptable standards. For many measurements, such calibrations are available from state or national authorities. In the range of higher doses applied in radiation processing, including food irradiation, official calibration is available through the International Atomic Energy Agency (IAEA) International

Dose Assurance Service.

Monitoring of the food itself should also be carried out to ensure that irradiated foods are safe and that they are irradiated only at the reasonably required dose and under conditions that will accomplish the intended technical effect. Sampling and analysis of raw materials, final products and foods during processing and storage should be carried out regularly in order to assure correct use of food irradiation.

**Voluntary compliance**

While it is necessary to have the ability to implement a good control policy, it is also desirable to promote voluntary compliance. When practised by manufacturers, importers and retailers, voluntary compliance is more effective and productive. Enforcement can, at best, be occasional, whereas voluntary compliance is continuous and permanent, emanating from the operators themselves.

To promote and encourage voluntary compliance, the responsible authorities should:

(a) Counsel the operators on health requirements - The industry should, through meetings, interviews and seminars, come to understand the responsible authorities concern and objectives in the area of food control.

(b) Provide technical advice - If the industry has difficulty in compliance because of a lack of knowledge or expertise, the authorities could assist by giving advice. Information booklets and materials to keep the food trade abreast of legislation and hygienic requirements should be freely distributed and explained.

(c) Actively promote quality control or quality assurance programmes - Such programmes serve to inform operators about the quality of their products and enable them to adjust and amend lapses of production, where necessary.

(d) Give recognition or incentives to operators who perform well - Factories or retailers which product food that complies with the regulatory requirements should be given official recognition.

**Certification of conformity with GIP**

International trade in irradiated food would be facilitated if there exists a harmonized or standardized system to control food hygiene, dosimetry, radiation safety and inspection procedures. Information on such a harmonized/standardized system could be reflected in a recognized certification method. Thus, a certification that the food to be imported has been irradiated in an authorized facility and under condition inspected for compliance with such authorization by competent national authorities, would be most desirable. The establishment of a certification system gains a special importance in the international trade in irradiated food as there does not exist an internationally agreed method or methods to detect whether food has been irradiated and at what dose level.

As internationally recognized standards/codes for food hygiene, dosimetry, good irradiation practice, labelling, training of operators of irradiation facilities and food inspectors, already exist, the ICGFI is in the process of developing an internationally recognized certification of conformity with GIP. Such a certification is being elaborated with the involvement of governments and industry, prior to finalization.

# TECHNICAL PARAMETERS TO BE STANDARDIZED WITH SPECIAL REFERENCE TO DOSIMETRY AND AUTHORIZED DOSES

P. ROBERTS
Nuclear Sciences Group, GSIR Physical Sciences,
Lower Hutt, New Zealand

## Abstract

The measurement of dose received - dosimetry - is fundamental to any irradiation processing operation. When food is processed, accurate dosimetry is required -

(i) to ensure that the facility is operating as designed in terms of personnel exposure;

(ii) to validate the dose absorbed by the food and, hence, to show that the process has met regulatory requirements and will produce the technical changes requested.

Routine exposures of the public and operating staff are well below recommended dose limits in any well designed and operated plant. Nevertheless, area and personal monitors must be available which have been calibrated by an approved testing service.

Product dosimetry is not a trivial exercise. It is impossible to irradiate food uniformly, and the dose distribution will vary with the geometry of the food and packaging and with the density. The dose distribution must be accurately known before radiation processing is commenced or Good Irradiation Practice (GIP) cannot be guaranteed. Once a product leaves the plant, it is impossible to independently check on the radiation treatment that was given.

Satisfactory dosimetry requires -

(i) access to a reference dosimeter, usually held by a national regulatory agency;

(ii) correct choice of a routine dosimeter which should be simple, reliable and cheap to use in industrial practice;

(iii) location and evaluation of the maximum and minimum dose points, and calculation of the overall average dose.

The principle reference and routine dosimeters will be described briefly and dose distribution calculations will be outlined.

Regulations may stipulate a maximum absorbed dose or maximum average absorbed dose as a safety limit based on chemical, microbiological or nutritional changes. For some foods, a minimum dose limit may also be imposed on safety grounds. Frequently, GIP requires the processor to provide a dose within a given dose range. The range required arises from a need both to maintain food quality and to ensure that the desired purpose of the treatment is attained. These technical limits to dose may or may not coincide with the safety limits. Countries deal with safety and technical limits in different ways. There is a need for authorities to understand more fully the purposes of the different types of limit and then to move towards a more harmonized system of regulating dose limits.

Food irradiation facilities must also handle foods in accordance with Good Manufacturing Practice (GMP). Issues requiring control to achieve GMP include -

(i) incoming goods - should be of good quality and, sometimes, meet microbiological criteria;

(ii) in-plant storage - must meet all necessary standards for temperature control, packaging, separation of unirradiated and irradiated food, and all building codes for premises storing food;

(iii) despatched product - must meet requirements for temperature control, packaging, shelf-life, labelling and documentation.

All these diverse issues must be understood and an integrated response obtained from authorities. The resulting system of control should ensure that the process is carried out in compliance with the principles of the Codex Standard. It should also provide straightforward guidance to industry, minimizing bureaucracy, but ensuring that the benefits of the process are delivered safely to confident, informed consumers.

**Introduction**

In 1988, 57 countries convened at an International Conference on the Acceptance, Control of and Trade in Irradiated Foods. The Conference adopted by consensus a document which set out several key principles that must be met when processing food by irradiation. These principles included -

- registration/licensing of the facility
- regulation and inspection of the facility
- proper documentation of the process and labelling of the product
- training of facility staff and regulatory officials
- employment of Good Manufacturing Practice (GMP) and Good Irradiation Practice (GIP)

In essence, the conference was endorsing the need for the food irradiation process to be consistent with the Codex General Standard for Irradiated Foods and the Codex Recommended International Code of Practice for the Operation of Radiation Facilities Used for the Treatment of Foods.

**Technical requirements for GMP and GIP**

There are many technical requirements to be fulfilled if GMP and GIP are to be met. Most of this talk will be devoted to the measurement of the absorbed radiation dose, but first, I will outline briefly some of the other important requirements. The extent to which there is international harmonization for each requirement is highly variable.

(i) Radiation sources

These are limited to $^{60}$Co, $^{137}$Cs and machine sources for electrons or X-rays operating at or below 10 MeV or 5 MeV respectively.

(ii) Hygiene

Irradiation is not a replacement for GMP or good hygiene practices at any stage of the pre or pos- irradiation handling of food products. In this way, irradiation will confer an additional benefit on the food.

Overall food hygiene standards should be harmonized by reference to the Codex Recommended International Code of Practice - General Principles of Food Hygiene, and to the Recommended International Code of Practice for a particular food, when available.

Proper food hygiene requires attention to -

- building standards (design, construction) and handling methods within the premises
- staff training
- temperature control. It is important that temperature control is maintained, for example, in foods in which there is a risk of formation of botulism toxin or aflatoxins
- packaging, including vacuum packaging. There is no international

agreement on packaging materials which are suitable for use in conjunction with irradiation. There are lists of materials approved for use in the USA and Canada

(iii) Microbiological criteria

GMP requires that, when received for irradiation, the unirradiated food should be as clean, wholesome and as uncontaminated as possible. Even with GMP, it is impossible to produce raw food that is completely free of microbiological contamination. It would be useful if authorities could agree microbiological criteria that, if met, would indicate compliance with GMP prior to irradiation. The criteria would be in the form of an upper limit of contamination and would be different for different foods.

The International Consultative Group on Food Irradiation (ICGFI), on behalf of FAO/IAEA/WHO, has convened an expert Consultation on Microbiological Criteria for Foods to be Further Processing Including by Irradiation. It is hoped that Codex will consider the findings of the consultation in its next session.

(iv) Documentation

Documentation must be sufficient to -

- identify irradiated foods by batch number

- trace the treatment given (source, dose, dosimetry, date, place, etc.)

- identify any required storage conditions (temperature, etc.)

- prevent re-irradiation unless specifically authorized

No harmonized system of documentation seems likely in the near future, but ICGFI is working on a Certificate of Irradiation Treatment of Food which could be recognized internationally.

(v) Labelling

Attitudes towards labelling irradiated foods differ in different countries, but the trend is towards requiring labelling. There is a Codex General Standard for the Labelling of Prepackaged Foods which has been amended as follows -

*"The label of a food which has been treated with ionizing radiation shall carry a written statement indicating that treatment in close proximity to the name of the food. The use of the international food irradiation symbol, as shown below, is optional, but when it is used, it shall be in close proximity to the name of the food.*

*When an irradiated product is used as an ingredient in another food, this shall be so declared in the list of ingredients.*

*When a single ingredient product is prepared from a raw material which has been irradiated, the label of the product shall contain a statement indicating the treatment."*

(vi) Codes of Good Irradiation Practice

ICGFI have issued Codes of Good Irradiation Practice for eight classes of foods

- cereal grains (insect disinfestation)

- prepackaged meat and poultry (to control pathogens and/or extend shelf-life)

- spices, herbs and other vegetable seasonings (to control pathogens and other microflora)

- bananas, mangoes and papayas (to extend shelf-life)

- fresh fruits (as a quarantine treatment)

- bulb and tuber crops (to inhibit sprouting)

- dried fish and salted and dried fish (insect disinfestation)

- fish, frog legs and shrimps (to control microflora)

It is hoped that these Codes will be adopted internationally as the standard for irradiation treatment of these foods.

**Dosimetry**

Radiation effects are brought about by the energy which is transferred from the ionizing beam or particle and absorbed in the food. The energy absorbed - commonly called the absorbed dose or just dose - is, therefore, the single most critical parameter to be controlled in radiation processing. The art of measuring absorbed dose is dosimetry, and the measurement systems are known as dosimeters. A hierarchy of dosimeters is available, as follows.

(i) Reference standard dosimeters

True primary standards for dosimeters have not been established. A few major laboratories (National Physical Laboratory (UK) or the National Institute of Standards and Technology (USA)) have developed reference standards which can provide a calibration service using well characterized gamma sources and radiation fields allied with graphite calorimeters and ionization chambers.

Calorimeters measure the energy absorbed as heat released into water. They have the advantage that measurement of the temperature rise in the water provides an absolute measurement of absorbed dose. Calibration against another radiation-measuring instrument is unnecessary. Ionizing chambers provide another physically-based method with the absorbed dose being measured by the number of ion pairs produced in air. Both dosimeters cover a wide dose and dose rate range.

(ii) Reference dosimeters

The reference standards can be used to calibrate other general reference dosimeters which are usually held by national facilities. A reference dosimeter can be any effect which varies detectably and reproducibly with dose. However, the common reference dosimeters are again calorimeters and ionization chambers, plus a few other dosimeters of which the Fricke ferrous sulphate dosimeter is perhaps the most common.

The Fricke dosimeter consists of an aqueous solution of ferrous sulphate and sulphuric acid. Free radicals produced during irradiation oxidize ferrous ions to ferric ions, a change detected as an increase in optical absorption. Thus, Fricke dosimetry is not a direct measure of absorbed dose, but the yield of oxidation product per unit of energy absorbed is so well characterized that the dosimeter is usually accepted as a reference. Doses in the range 10 - 400 Gy can be measured, and a small modification to the solution extends the range to 2 kGy.

(iii) Transfer dosimeters

A transfer dosimeter is one that is reasonably precise, and is also sufficiently stable and robust so that it can be transferred between laboratories, from a commercial facility to a specialized national dosimetry laboratory, for example. Their major use is in calibration and intercomparison services.

Solid systems are advantageous for transfer dosimeters. The alanine dosimeter comprises small rods of 90% L-alanine in 10% paraffin. Absorbed dose is measured by the stable signal of free radicals trapped in the solid matrix which is detected by electron spin resonance. The dosimeter is sensitive over a wide dose range (up to 100 kGy). Radiochromic films, which contain organic dyes in a plastic matrix and which become deeply coloured after irradiation, are also useful transfer dosimeters.

(iv) Routine dosimeters

Most reference dosimeters are too complex, fragile or costly to be used routinely within a commercial plant. More practical dosimeters for commercial use comprise plastic materials such as polymethylmethacrylate. Small pellets or thin strips of the plastic, either clear or coloured by a dye, change colour over a wide dose range. The colour change induced gradually fades. Such dosimeters are the type used to check dosimetry routinely within irradiated food packages.

(v) General

There are many types of dosimeter.

Tables 1 and 2 list those readily available. A detailed discussion of their construction and operation is beyond the scope of this lecture. They are fully described in text books such as "Dosimetry for Radiation Processing" by McLaughlin, Boyd, Chadwick, McDonald and Miller. In addition, the American Society for Testing and Materials (ASTM) is developing methods and standards of dosimetry, including standards for food processing.

**Traceability**

An essential part of dosimetry is that the measurements made within a facility must be traceable to measurements made in a national standards laboratory using a well-calibrated radiation source and reference standard dosimeters. If a national standards laboratory does not have the resources to provide a full reference standard dosimeter, it should have its radiation source and reference dosimeter calibrated by an inter-comparison with a laboratory that has such facilities.

Traceability can be established in any of three ways (Figure 1). First, the national facility can provide transfer dosimeters which are used at the food irradiation plant and then returned to the national facility to be read. Second, the national facility can calibrate samples of a large batch of routine dosimeters. The dosimeters are then used in the plant and read within the plant using the calibration information provided. Third, the national facility can provide and read transfer dosimeters which are used to calibrate a radiation source and field in the plant. This calibrated source can then be used to provide a full in-house dosimetry service for the plant. These methods can all be provided within a country that has an adequate national facility.

For countries without an adequate national facility or, more likely, to assist in calibrating the reference dosimeter system of a national facility, the IAEA Dose Assurance Service (IDAS) can be used. IDAS can also provide a direct calibration service for commercial plants. As trade in irradiated food increases, IDAS may well have a role to play in providing international cross-comparisons and independent assurance that foods crossing international boundaries have been irradiated at the specified doses.

The aims of IDAS are:

- to provide a 'dose assurance' service to promote dosimetric accuracy in products processed in irradiation facilities in IAEA member states; and

- to provide regulatory health authorities concerned with trade of irradiated products with the confidence that such products have been irradiated to the specified absorbed dose.

**Dosimetry for worker safety**

Dosimetry is an essential part of calibrating area and portable survey monitors and of measuring worker exposures through the use of personal dosimeters, such as the lithium fluoride thermoluminescent dosimeter or the photographic film badge. Details may be found in any text book on Health Physics or Radiation Protection.

**Dosimetry of food products**

Once an irradiated food product has left the plant, there is no satisfactory method for independently confirming the dose that was applied. Thus, in-plant dosimetry is the only way to guarantee and to record that specified treatments have been provided. Dosimetry must be carried out to -

- commission a new facility. This should fully describe the basic operational parameters of the facility (e.g. dependence of absorbed dose on source strength, conveyor speed, product density, etc.)

- validate a new process. This should fully describe the dose received throughout a product/packaging system prior to a new food being irradiated or a new treatment being initiated.

- ensure quality control. This should routinely measure the dose received throughout sample packages, typically 1 in every 20 packages.

(i) Dose distribution

It is inevitable that the dose received within a food package will not be uniform. This is because the absorbed dose decreases as the distance from the source increases and as the radiation penetrates into the food. As a result, there is a distribution of doses throughout the package (Figure 2).

There will be positions of maximum and minimum dose, $D_{max}$ and $D_{min}$. The ratio $D_{max}/D_{min}$ is known as the Dose Uniformity (DU). Good Irradiation Practice requires DU to be as near unity as possible. Acceptable DU values differ for different foods and processes. DU is usually minimized by irradiating the package from two sides (see Figure 2).

The validation of a new process requires the dose distribution throughout the package to be fully mapped (Figure 3). Routine dosimeter (the plastic strip type, for example) are placed throughout sample packages and irradiated as if being actually treated. The dose mapping determines the dose distribution and the position of $D_{max}$ and $D_{min}$. Routine process control requires the dose at the positions of maximum and minimum dose to be measured in sufficient packages, say 1 in 20, to establish the mean $D_{max}$ and $D_{min}$ with reasonable certainty.

Figure 4 shows how routine dosimetry at the positions of maximum and minimum dose is used. The distribution of dosimeter readings will establish the mean and the range of $D_{max}$ and $D_{min}$ values. These will be compared with the upper and lower dose limits that have been set by regulatory authorities. Probably the management of the plant will set 'in-house' targets to be met that are slightly more restrictive than the dose limits in order to ensure compliance with the limits. The management of the plant should also set 'action levels' whereby corrective action is taken if the mean values of $D_{max}$ or $D_{min}$ alter significantly from the original values.

(ii) Overall average absorbed dose

The dose mapping exercise also permits an overall average absorbed dose, $D_{AV}$, for the package to be calculated. The Codex General Standard defines the maximum permitted absorbed dose in terms of an overall average. $D_{AV}$ is rigorously defined as -

$$D_{AV} = \frac{1}{M} \int p\,(x, y, z)\; d\,(x, y, z)\; dV$$

where,
M = total mass of product
p = density at (x, y, z)
d = absorbed dose at (x, y, z)
dV = infinitesimal volume element
(x, y, z) = co-ordinates defining a given point

However, the following simple approximation is often sufficient

$$D_{AV} = \frac{D_{max} + D_{min}}{2}$$

(iii) Dose limits

There are two types of dose limits. The first type is a legal limit. Legal limits are set by regulatory authorities and should be backed by the power of the law. The limits are set by safety considerations. An upper legal dose limit is set by the highest dose considered safe or prudent by virtue of the chemical, nutritional or microbiological changes that irradiation can cause in food. Legally-enforced lower dose limits are only necessary for certain processes. One example would be a process in which a failure to deliver a minimum dose could lead to a public health hazard, such as failure to reduce Salmonella numbers as intended in chicken which is subsequently sold as having an extended shelf-life. Another example would be fresh fruits irradiated to eliminate insect pests, in which failure to deliver the minimum dose could imperil quarantine security measures.

The second type of limit is a technical limit. Technical limits are set to ensure compliance with GMP and GIP and do not necessarily require legal enforcement. An upper technical limit is set by the maximum dose which a food can tolerate. Above this limit, there is a clear loss of quality (taste, texture, smell). A lower technical limit is set by the minimum dose required to ensure that the benefit intended and claimed actually occurs.

(iv) Statistical considerations

There are statistical problems which must be recognized when defining dose limits. Doses are distributed statistically throughout the food package; there is also a statistical uncertainty associated with the measurement of any dose, including $D_{max}$ and $D_{min}$.

Without further definition, $D_{AV}$ could be met by giving zero dose to 50% of a package and twice $D_{AV}$ to the other 50%. This is an absurd example, but it illustrates that it is necessary to define limits to the uncertainty on dose measurements that is acceptable.

Codex states that the maximum absorbed dose should be equal to a $D_{AV}$ of 10 kGy. If further states that 97.5% of the product should receive less than 15 kGy if $D_{AV}$ is 10 kGy.

(iii) Lack of harmonization

Because of the different types of limits and the statistical nature of the defined parameters, there is considerable opportunity for different countries to approach dose limitation in different ways.

An examination of the dose limitation systems used in different countries reveals that there may be:

- definition in terms of $D_{AV}$ or $D_{max}$ and $D_{min}$
- limits of uncertainty defined/not defined
- limits to Dose Uniformity defined/not defined
- an upper limit only, based on safety
- an upper limit only, based on technical considerations
- an upper and lower limit based on safety considerations
- an upper and lower limit based on technical considerations
- a combination of the above
- limits set for specified foods/food classes/all foods

If trade in irradiated food is to occur more widely, it will be essential for trading partners to have confidence that they know and understand what dose limitation system has been imposed. One of the most pressing topics on which countries need to agree is a harmonized system of dose limitation within national regulations.

**Summary**

The maintenance of GMP and GIP is essential to the safe and beneficial treatment of food by irradiation to provide a process which can be permitted by regulatory authorities and trusted by consumers. GMP requires a number of measures to ensure adequate food hygiene is achieved at all stages in the handling of food. Proper control of the dose is the single most important factor involved in GIP. Adequate dosimetry using appropriate systems within the irradiation facility that are traceable to national standards is therefore an essential part of GIP. Only through adequate dosimetry can compliance with legal and technical dose limits be ensured. There is a need to seek harmonization of the systems of dose limitation used in different countries if trade in irradiated foods is to be facilitated.

Table 1 Liquid chemical dosimeters for high doses[a]

| Solute | Solvent | Methods of analysis | Approximate usable range of absorbed dose (Gy) |
|---|---|---|---|
| ferrous sulphate | aerated aqueous $H_2SO_4$ | UV spectrophotometry | $2 \times 10 - 2 \times 10^2$ |
| ferrous sulphate | oxygenated $H_2SO_4$ | UV spectrophotometry | $4 \times 10 - 2 \times 10^3$ |
| ferrous cupric sulphate | aerated aqueous $H_2SO_4$ | UV spectrophotometry | $5 \times 10^2 - 5 \times 10^3$ |
| ceric-cerous sulphate | aerated aqueous $H_2SO_4$ | UV spectrophotometry or electrochemical potential | $10^3 - 10^6$ |
| potassium dichromate | aerated aqueous $HClO_4$ | UV-visible spectrophotometry | $5 \times 10^3 - 4 \times 10^4$ |
| silver dichromate | aerated aqueous $HClO_4$ | UV spectrophotometry | $10^3 - 10^4$ |
| sodium formatede | aerated $H_2O$ | colorimetric titration | $10^4 - 10^6$ |
| oxalic acid | aerated $H_2O$ | colorimetric titration | $5 \times 10^3 - 10^6$ |
| potassium iodide | water + $H_2O_2$ ($H_2$ and $O_2$ saturated) | gas pressure | $5 \times 10^5 - 10^8$ |
| benzene | aerated $H_2O$ | NaOH + UV spectrophotometry | $5 \times 10 - 7 \times 10^2$ |
| chlorobenzene | aqueous ethanol | titration with indicator or HF oscillometry | $10^3 - 10^5$ |
| radiochromic leuco dyes | various organic solvents | visible spectrophotometry | $10 - 10^4$ |
| bleachable dyes | water | visible spectrophotometry | $10^2 - 10^5$ |
| indicator dyes | halogenated hydrocarbons | colorimetry titration, visible spectrophotometry | $10^1 - 10^4$ |
| polyisobutylene | heptane | viscometry | $10^1 - 10^8$ |

[a] Adapted from Mclaughlin et al. (1990), "Dosimetry for Radiation Processing".

Table 2 Solid dosimeters for high doses[a]

| Material used | Methods of analysis | Approximate usable dose range (Gy) |
|---|---|---|
| *Solid-state* | | |
| amino acids | ESR | $1 - 10^5$ |
| amino acids | lyoluminescence | $10^3 - 10^6$ |
| glucosides | lyoluminescence | $1 - 10^3$ |
| glucosides | optical rotation | $10^4 - 10^6$ |
| anthracene, naphtalene | luminescence degradation | $10^4 - 10^8$ |
| LiF | TLD or<br>spectrophotometry | $10^5 - 10^5$<br>$10^2 - 10^9$ |
| $Li_2B_4O_7$ | TLD | $10^2 - 10^5$ |
| $CaF_2$: Mn | TLD | $10^6 - 10^3$ |
| $CaSO_4$. Dy | TLD | $10^1 - 5 \times 10^6$ |
| AgBr, AgCl (emulsions) | IR densitometry | $10^2 - 10^6$ |
| Si, $SiO_2$ | voltage or current measurement | $10^2 - 10^6$ |
| *Glasses* | | |
| cobalt glass | visible spectrophotometry | $10^2 - 2 \times 10^4$ |
| $AgPO_4$ glass | visible spectrophotometry | $10^1 - 10^4$ |
| Bi-Pb-$BO_4$ ($AsO_3$) | visible spectrophotometry | $10^3 - 10^7$ |
| *Plastics* | | |
| cellulose triacetate | UV spectrophotometry | $10^4 - 10^6$ |
| polymethylmethacrylate | UV spectrophotometry | $10^3 - 10^5$ |
| polyethylene terephthalate | UV spectrophotometry | $10^4 - 10^7$ |
| polyhalostyrenes | UV spectrophotometry | $10^4 - 10^6$ |
| polyethylene | UV and IR spectrophotometry | $10^5 - 10^6$ |
| polyvinyl chloride | UV spectrophotometry | $10^4 - 10^5$ |
| stilbene in polystyrene | UV and visible spectrophotometry | $10^3 - 10^6$ |
| *Dyed plastics* | | |
| polymethylmethacrylate | visible spectrophotometry | $10^3 - 5 \times 10^4$ |
| cellophanes, celluloids | visible spectrophotometry | $10^4 - 10^6$ |
| polymide | visible spectrophotometry | $10^2 - 10^5$ |
| polyvinyl butyral | visible spectrophotometry | $10^2 - 10^5$ |
| poly (halo) styrene (e g poly (chloro) styrene) | visible spectrophotometry | $10^3 - 10^6$ |
| polyvinylchloride | visible spectrophotometry | $10^3 - 10^5$ |
| cellulose triacetate | visible spectrophotometry | $10^3 - 10^5$ |
| polyvinylalchol | visible spectrophotometry | $5 \times 10^3 - 10^5$ |

[a] Adapted from McLaughlin et al (1990), "Dosimetry for Radiation Processing".

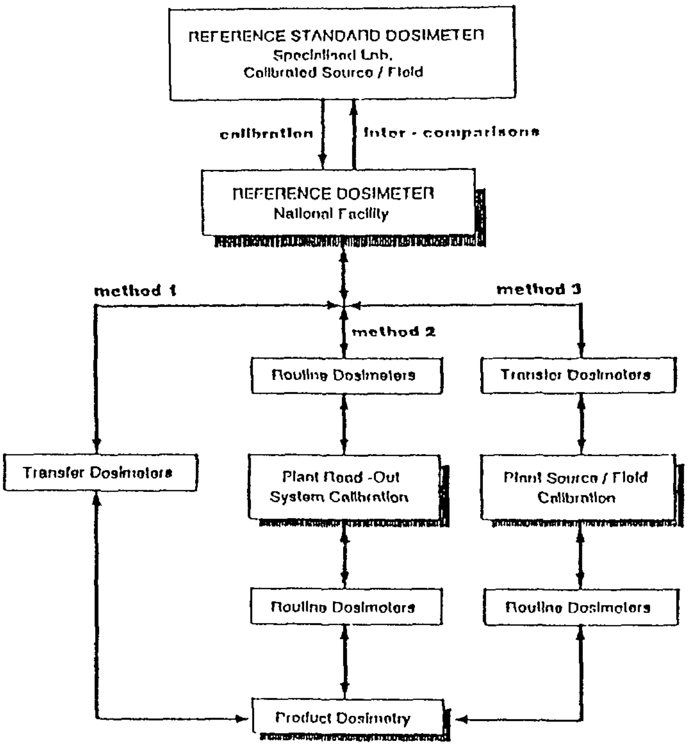


Fig.1. Methods to ensure adequate in- plant dosimetry with traceability to a reference standard dosimeter.

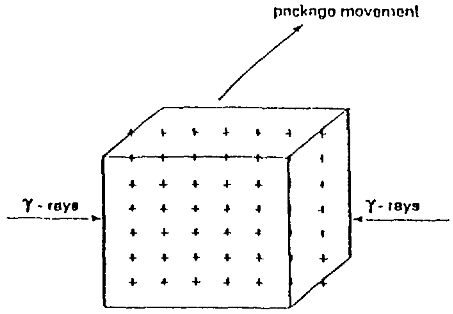


Fig. 3. Placement of dosimeters ( + ) in a dose mapping exercise.

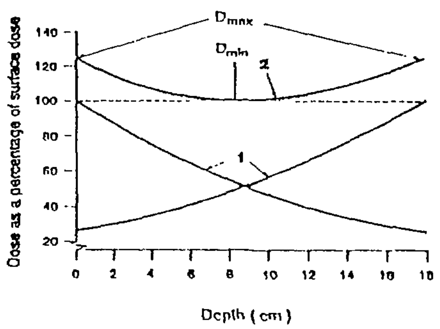


Fig. 2. Distribution of dose with depth in a food package for gamma irradiation of unit density material from one side (1) or two sides (2).

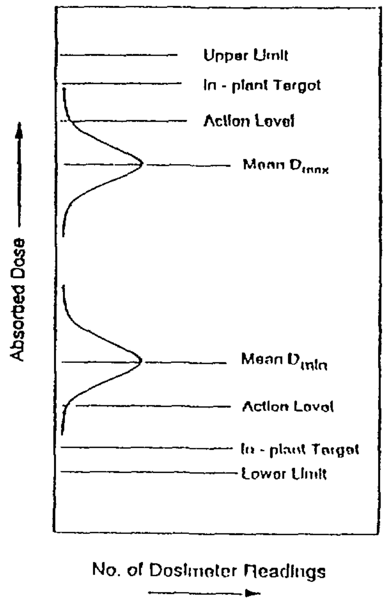


Fig. 4. Relationship between dose limits and routine dosimeter readings at the positions of maximum and minimum dose.

# ENVIRONMENTAL IMPACT ASSESSMENT IN THE ESTABLISHMENT OF FOOD IRRADIATION FACILITIES

P. ROBERTS
Nuclear Sciences Group, DSIR Physical Sciences,
Lower Hutt, New Zealand


## Abstract

The Codex Standard for Irradiated Foods permits the use of four sources of radiation. They are X-rays with a maximum energy of 5 MeV, electrons with a maximum energy of 10 MeV, $^{137}Cs$ and $^{60}Co$. None of these sources can induce radioactivity in any material through which they pass.

X-rays and electrons are produced in particle accelerators. These are electrically driven machines and without power no radiation is produced. They have the advantage that no transport of radioactive material is involved. Accelerators are perceived as involving no environmental hazard. They are not without environmental cost, however, since they require a considerable supply of electric power and substantial cooling water.

Two accelerators irradiate grain in Russia and another commercial accelerator is used for food irradiation in France. More generally, however, technical reasons dictate that most accelerators for food irradiation have been research-related rather than truly commercial.

At least one commercial irradiator has $^{137}Cs$ as its source, as have several small research facilities. However, $^{137}Cs$ can only be supplied in commercial quantities by the chemical processing of spent reactor fuel. It is produced in a form which is soluble and has a low melting point. These factors make it unattractive from an environmental perspective, and it is unlikely to find substantial commercial use. Some governments have banned its large scale use.

Most commercial food irradiation facilities have, therefore, used $^{60}Co$ as the radiation source. The manufacture and physical characteristics of $^{60}Co$ sources will be described, and the basic operation of $^{60}Co$ facilities will be outlined. In routine use, the environmental impact of such a plant is negligible. A series of potential accident scenarios will be discussed with the conclusion that $^{60}Co$ irradiation should be regarded as a very safe industrial activity.

The greatest environmental concern is directed towards the transport of the source to and from the facility, and its eventual disposal. International guidelines are available for the transport of $^{60}Co$ sources used in radiation processing and the safety record is impressive. The potential for dispersal of the source material is probably not as great as generally imagined.

Technically, disposal of the source is not a problem. It can be shipped back to the supplier and re-irradiated to generate more $^{60}Co$. Accidents with other types of radioactive sources indicates a need for a stable regulatory infrastructure to ensure a proper transport and eventual disposal of radioactive sources.


## Introduction

The Codex General Standard for Irradiated Foods restricts the types of radiation which can be used to treat foods to -

- gamma-rays from the radionuclides $^{60}Co$ or $^{137}Cs$

- X-rays from machine sources operated $\leq$ 5 MeV

- electrons from machine sources operated $\leq$ 10 MeV

The energy of such radiation is sufficient to bring about chemical reactions in food or any material through which the radiation passes. However, the energy of the gamma rays is not sufficient to induce any changes in the nucleus of the atoms of the material irradiated. Therefore, it is impossible to make anything radioactive through irradiation in a $^{60}Co$ or $^{137}Cs$ irradiation plant. Calculations show that 5 MeV X-rays and 10 MeV electrons can induce trivial amounts of radioactivity which is far less than the natural radioactivity in food and which, in fact, is so low that it cannot be measured even by sensitive detectors. In summary, the radiation sources used for food irradiation cannot make anything measurably radioactive. The assessment of the environmental hazards of food irradiation facilities can be limited to the possibilities for direct exposure of people to the source material. It is generally recognized that if people are adequately protected then the rest of the environment, other animals and plants, will also be adequately protected.

**General facility design**

Food irradiation plants comprise mainly warehouse space for the receiving, storage and despatch of the products requiring treatment. The radiation source is placed inside a thick concrete shield which absorbs the radiation emitted when the source is operating and ensures that the exposure of the staff is very low. Food is carried inside the irradiation chamber, usually automatically, via a maze system which is designed to reduce any escape of the radiation into areas occupied by staff.

**Machine sources**

Electron beam radiation is produced in a particle accelerator. However, a beam is only produced if the machine is supplied with electric power. If the machine is switched off, there is no radiation beam. No radioactive material is involved at all.

10 MeV electrons penetrate only four millimetres into concrete. Therefore, it is easy to shield against exposure from electrons. However, when the electrons are suddenly stopped by absorbing materials, particularly some metals, X-rays are produced which are very penetrating. Because some X-ray production is inevitable, even electron sources need to be surrounded by a thick concrete shield.

From an environmental perspective machine sources are very attractive. They involve no radioactivity; this frees them of the public perception of risks associated with transportation, handling and disposal of radioactive sources. However, they do use considerable electric power and cooling water. A 10-100 kW accelerator can require many litres of water per second and the larger accelerators can require cooling towers.

Despite their environmental attractiveness, at the present time, machine sources are of limited use for commercial food irradiation. Electrons do not penetrate far into materials and cannot be used for food in bulky packages or pallet loads. Electrons are being used to disinfect grain, moving as a thin stream, and to decontaminate mechanically separated poultry meat in packs 70-80 mm thick.

A penetrating source of radiation is obtained if the electrons are deliberately converted to X-rays by placing a metal target in front of the beam. However, the conversion process is very inefficient, making X-ray sources relatively expensive. X-rays have not been used commercially for processing.

**Gamma-ray sources**

Most food irradiation plants are gamma-ray facilities for reasons which include the excellent penetration properties of gamma rays and their simplicity, reliability, and straightforward dosimetry.

A feature of gamma-ray sources is that radiation is being continuously emitted. This means that when the source is not being used or to gain safe access to the irradiation chamber, the source must be lowered into a pool of water in order to absorb all the gamma rays. The pool is usually about 7 m deep. The continuous emission also means the source is continuously decaying and must be replenished at intervals 10% of the activity of a $^{60}Co$ plant is replenished annually which means that during the life of the plant, radioactive material must be transported to it on many occasions.

(i) $^{137}$Cs sources

$^{137}$Cs is frequently used in research irradiators. However, $^{137}$Cs is only produced by the fissioning of uranium in nuclear reactors, and is only available after reprocessing of the nuclear fuel rods. In practice, it would be very difficult to produce enough $^{137}$Cs to source a significant number of commercial-scale irradiators and, therefore, $^{60}$Co has dominated the gamma-plant market.

$^{137}$Cs also has a number of environmental drawbacks and some countries (e.g. New Zealand and Australia) will not permit its large scale use. The environmental concerns include the fact that it is usually produced as a powder which is harder to encapsulate reliably and which is soluble, has a low melting point and is easily vaporised. Although mishaps will be rare, it will be harder to guarantee source integrity than is the case with $^{60}$Co sources, and harder to contain any leakage of radioactivity or to deal with the resulting contamination.

In addition, the environmental risks of the reprocessing operation should be taken into account. However, reprocessing is probably more of a socio-political problem than a strictly environmental one. The reprocessing operation is essentially part of a process which can ultimately produce weapons grade plutonium, and it is this aspect of $^{137}$Cs production that is of concern to some people.

(ii) $^{60}$Co sources

Irradiation plants for the sterilization of medical products are predominantly $^{60}$Co plants; as the number of commercial facilities for food irradiation increases, it is likely that this market will also be dominated by $^{60}$Co plants, at least until technical advances can make X-ray sources economically competitive.

$^{60}$Co plants have among their attractive features great simplicity of operation. When not operating, the source is kept at the bottom of the pool. To irradiate food packages, a simple mechanical hoist brings the source out of the pool into the centre of the conveyor system. In the event of any mishap, the source is simply lowered back into the pool. A number of workers have been accidently irradiated by entering the irradiation chamber when the source was still in its operating position. In all cases, however, there had been a blatant disregard, abuse or wilful tampering with the safety system designed to ensure worker safety. One simple rule would prevent exposure. Never enter the chamber without a properly functioning radiation monitor.

The major supplier of $^{60}$Co and of irradiation plants is Nordion Limited (formerly Atomic Energy of Canada Limited). I shall base my description of a $^{60}$Co source on a typical Nordion design.

$^{60}$Co is produced by irradiating the stable element, $^{59}$Co, in a reactor for about a year. The cobalt is 99.9% pure cobalt metal. Small slugs of cobalt are coated by nickel plate and then doubly encapsulated, first in a sheath of zircalloy and then a final capsule of stainless steel. This produces a source pencil, usually about 10 mm in diameter and 210 mm long. A number of source pencils are then mounted on a metal frame called a module (typically 0.5 m x 0.5 m). Several modules are placed on a rack with the overall dimensions dictated by the overall plant design and throughput.

The source pencils are extremely resistant to corrosion and they are subjected to rigorous tests involving extreme temperatures, impact, puncture and vibrational stresses. The track record of the Nordion source pencils is impressive.

However, suppose a source pencil were to corrode, what would happen? Cobalt metal is highly soluble and any released cobalt metal will simply stay undissolved and quite safe in the bottom of the pool. We will examine a number of accident scenarios below. However, the basic properties of cobalt, an insoluble, high melting point metal, mean that it is not possible for the cobalt to be dispersed widely in environment.

**Accident risks**

(i) The pool

The pool is constructed of concrete

with a stainless steel liner. It is leakproof. As part of the anti-corrosion measures, the water is circulated through de-ionising columns and is very pure. Any small leakage and dissolution of $^{60}Co$ into the water would be immediately retained in the de-ionisers and detected by detectors mounted on them.

(ii) Earthquake

Seismic detectors withint the plant are triggered during earthquakes and the source is returned into its safe position in the pool within a few seconds. A massive earthquake could conceivably crack the pool and its liner, and water would leak into the ground. However, the water is not contaminated or radioactive. If the source rack was damaged, source pencils could fall to the bottom of the pool. Provided water remained in the pool, there would be no hazard.

If most of the water is lost from the pool, then there will be a direct radiation hazard from the exposed source. However, the concrete shield around the building would still protect the general environment. It could be argued that a very severe earthquake could damage the radiation shield and also prevent the source from being lowered into the pool. Even this is far less of a hazard than might be imagined. If a commercial $^{60}Co$ source was completely unshielded, it would pose a direct radiation risk out to perhaps one kilometre; lethal dose levels would be restricted to within about 100 m of the source.

It is impossible to imagine any event that would leave the source completely unshielded. The concrete shield structure is so massive that any natural event, such as an earthquake, capable of even partly damaging it, would also inflict damage to life and property over an area much greater and on a far larger scale than any hazard due to radiation.

(iii) Fire

Smoke and temperature sensors are located within the plant. In the event of fire, the source is lowered automatically into the pool. Should the mechanism for lowering the source fail simultaneously, there is still no risk of $^{60}Co$ being dispersed into the environment. The all-metal source would require far higher temperatures to melt and vaporise the $^{60}Co$ than could be generated by the limited combustible material to be found within the irradiation chamber.

(iv) Explosion

A $^{60}Co$ source is not a nuclear reactor or a bomb. It cannot melt-down or explode. It would be possible for terrorists or saboteurs to cause an explosion within the plant. It would not be possible to cause environment contamination over more than a very limited local area.

(v) Summary

A number of other most likely accident risks can be imagined (e.g. an aircraft crashing on the building). However, the risks considered above are sufficient to show that:

(i) the properties of metallic $^{60}Co$ make it very difficult to cause widespread contamination of the environment; and

(ii) any event which would cause radioactivity to reach outside the plant would be extremely unlikely; it would also be an event that would cause other types of widespread devastation that would far outweigh any radiation problem.

**Transportation of source**

Public concerns are frequently voiced about the risks of transporting $^{60}Co$ in relatively large quantities to the plants. Transport of the sources should comply with the International Atomic Energy "Regulations for the safe transport of radioactive material".

$^{60}Co$ is transported in specially tested Type B transport packages. The packages are approximately 1 m in diameter, 1.5 m high and weight 5 tonnes. The weight is due to a 266 mm thick lead shield which is encased in steel. Type B packages are designed and tested to withstand accident conditions. The tests include:

- dropping the package from a

height of 9 m onto a hard surface

- heating to 800°C for 30 minutes

- pressure tests equivalent to 15 m of water.

In a ten-year period (1971-1981), there were 750,000 movements of Type B packages in the US alone (most would be material other than $^{60}Co$). Of course, some accidents involving packages occurred in that period, about 50 in all. In no accident was the package damaged so as to result in loss of shielding or escape of radioactivity. This record has continued to the present. When this record is added to the properties of $^{60}Co$ discussed earlier, the hazards of transporting $^{60}Co$ are negligible.

**Quantitative risk assessment (operation and transport)**

In 1987, Arthur D Little International carried out a Quantitative Risk Assessment (QRA) for a proposed three million curie irradiation plant in Auckland, New Zealand. The methodology and conclusions of the QRA have been independently reviewed by a Dutch consulting company, Save Consultants.

The QRA considered all forms of operational accidents and external hazards such as fire, earthquakes, aircraft impact and also severe transport accidents. Over 50 pathways in which radioactivity could come into contact with the public and environment were evaluated. The conclusion was that the highest risk to the public and the environment came from severe transport accidents and from a massive volcanic eruption near the irradiation plant. Such an eruption is only likely once in every million years or so, even in a volcanically active country like New Zealand.

The QRA concluded - *"The worst case scenarios ..... could lead to limited amounts of radiation dose to small groups of people in limited areas, but then only with probabilities of occurrence that are very small"*.

SAVE Consultants concluded - *"the individual risk due to transportation and the radiation process is far less than $1 \times 10^{-8}$ per year.*

*The group risk is estimated to be less than 10 fatalities with a cumulative frequency less than $2 \times 10^{-8}$ per year.*

*As far as risks resulting from external impact are concerned (aircraft crashes, volcanoes, earthquakes), SAVE Consultants agree that the additional risk due to the presence of radioactive material outside the chamber is far less than the risk due to the impact itself".*

Risks of this low probability are orders of magnitude lower than the risks from many industrial activities accepted as commonplace by modern society.

**Disposal of source material**

The source rack is designed to have extra source pencils added to compensate for the decay of the original pencils and the original pencils need not be removed for many years. Eventually, however, it may be necessary to dispose of the source pencils.

Unwanted pencils can be transported back to the supplier in the same safe manner in which they were brought into the plant. The used pencils can be re-irradiated to generate more $^{60}Co$, effectively recycling the source.

There have been accidents, fatalities and some environmental contamination due to the improper disposal, storage or surveillance of unwanted gamma sources including $^{60}Co$ and $^{137}Cs$ sources. Notable accidents have occurred at Juarez (Mexico) and Goiana (Brazil) for example. These incidents occurred partly because the activities involved were sufficiently small or sufficiently shielded for the sources to be moved or broken up without any immediate effect on the people involved.

The large activity and size of the $^{60}Co$ sources associated with commercial irradiators make similar accidents most unlikely. The exposed source simply cannot be forgotten, nor can it be approached without being almost immediately lethal.

However, the accidents that have occurred do point out the necessity of having a stable and effective regulating system in place to monitor and track the location, ownership and ultimate disposal of radioactive sources.

## Conclusions

Commercial food irradiation plants require an independent, competent regulatory authority to ensure that all aspects of the operation of the plant are carried out with minimal risk. The design of plants and the inherent properties of both machine and $^{60}Co$ sources ensure that the risks to the environment are negligible, and certainly far lower than those associated with many other industrial operations.



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## TECHNICAL BASIS OF REGULATORY CONTROL OF IRRADIATED FOOD IN TRADE

(Session IV)

**Chairman**

**P. ROBERTS**
New Zealand

# LABELLING OF IRRADIATED FOODS (INCLUDING SHIPPING DOCUMENTS) AND OTHER PROVISIONS RELATING TO THE PRODUCT MOVING IN TRADE

L.G. LADOMETRY
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture,
International Atomic Energy Agency, Vienna

*Presented by P. Loaharanu*

## Abstract

Radiation treatment of food is intended to achieve a technological effect without changing the identity of the product. Thus, the technology can be compared with refrigeration (without freezing), chemical fumigation, pasteurization, and packaging under controlled atmosphere. Since an irradiated food is not changed, the same standards and regulations apply to the irradiated food product as apply to the unirradiated counterpart. The question then is what can be controlled on the irradiated food moving in trade?

The answer is: whatever would have been controlled had the food not been irradiated; and in addition certain radiation related parameters. The following is a list of such parameters, which apply only to irradiated food products.

(a) Has irradiation treatment been carried out in accordance with good practices (i.e. in accordance with regulations)? - This can be ascertained from records kept by the irradiation facility, which may be on a national and/or international inventory (register) of authorized facilities, or through the issue of certificates;

(b) Has the technological purpose been achieved? - Most of the applications of irradiation treatment are self-enforcing, i.e. enforced by the owner of the product and the irradiator. However, some applications require regulations and inspection by the responsible authorities (e.g. in improving hygienic quality by eliminating pathogens and parasites and in plant quarantine control);

(c) Has the product been labelled in accordance with the relevant regulations? - This is an obvious and rather easy parameter to check in the light of the labelling requirements of the importing country. "Labelling" means the presentation of information on the "label", in accompanying documents or displayed near the food. The lecture will discuss the Codex Standards on Labelling and the pros and cons of labelling irradiated foods;

(d) Has the product been suitably packaged? - good irradiation practice involves the proper packaging of food, as with any food or treatment. The selection of suitable packaging materials and forms of packaging, including atmosphere control is a matter for the food industry and the food irradiator to ensure in order to protect the food and to ensure its hygienic quality. Some countries have lists of permitted packaging materials suitable for food irradiation;

(e) Has the product been irradiated? If so, has any legal limits for absorbed radiation doses been respected? The role of legal limits (minimum or maximum) for absorbed doses of radiation will be briefly discussed as well as the means of detecting whether a food has been irradiated and the determination of absorbed dose.

Radiation treatment of food is intended to achieve a technological effect without changing the identity of the product. Thus, the technology can be compared with refrigeration (without freezing), chemical fumigation, pasteurization, and packaging under controlled atmosphere. Since an irradiated food is not changed, the same standards and regulations apply to the irradiated food product as apply to the unirradiated counterpart. The question then is how can irradiated food moving in trade be controlled?

The answer to this question is very simple. An irradiated food product must comply with the standards and regulations which apply to the corresponding unirradiated food. In addition, specific regulations for irradiated foods generally also apply. Finally, an irradiated food product must have the characteristics which were intended to be achieved through irradiation treatment. This latter aspect may be covered in regulations (e.g. microbiological quality, absence of viable quarantine pest) or may be a matter between exporter and importer and the irradiation facility (e.g. shelf-life extension, absence of sprouting). There is another category of irradiated food products which require, or will require, specific standards and requirements. Examples of these are sterile foods for immuno-suppressed persons, special products for astronauts, shelf-stable foods which otherwise would have required refrigeration or some other form of preservation, etc.

In the previous sessions of this Seminar, the various parameters requiring control in the irradiation facility and during processing were discussed. This paper deals only with those aspects which are irradiation specific and which relate to the finished irradiated food moving in trade.

**Authorization of application of food irradiation treatment and mandatory or advisory limits for absorbed radiation dose**

Nearly all countries which have authorized irradiation of foods have done so on a product-by-product basis or on a group of products basis. This approach by governments makes it necessary to check whether a food entering trade has or has not been irradiated. Potentially, this can be a formidable task, requiring reliable and efficient methods of monitoring.

In addition, governments are setting minimum or maximum limits for absorbed radiation doses for individual food products or groups of food. These limits, which are usually mandatory rather than advisory under national regulations, require enforcement. A very effective way of doing so is through the inspection, by national authorities, of records kept in the facility in the exporting countries, and registration of the facilities and proper regulatory control of the process. The issue of a certificate by the irradiator describing certain irradiation parameters can also be used as an indication of good irradiation practices and compliance with mandatory limits for absorbed dose.

Quantitative analytical methods for the determination of absorbed radiation dose are being developed. However, determination of such doses in the sample taken from a consignment of irradiated foods moving in trade cannot provide useful information on good irradiation practice. As with any processing, this must be controlled in the facility.

**Achievement of the technological purpose**

Food irradiation is a physical treatment which is applied to food for a specific purpose. Certain applications should be subject to specific regulatory measures; others are self-regulating. For example, treatment of mangoes for quarantine purposes will evidently have to be controlled by the competent authority just as fumigation treatment or treatment by refrigeration or other physical treatment are controlled. A food product treated to eliminate pathogens or parasites will, no doubt, be checked for microbiological quality as with other forms of processing. On the other hand, other applications such as extension of shelf-life, delaying ripening, prevention of sprouting and reduction of total microbial load will be certainly controlled by the industry itself. National food control authorities will also be involved when claim are made on the label in connection with the food treated by irradiation.

## Packaging of irradiated foods

Just like any other foods, irradiated processed foods have to be packaged in an appropriate manner. Any general provision in the food law and regulations requiring the use of appropriate packaging and packaging materials are applicable to irradiated foods. Results of extensive research have shown that almost all commonly used food packaging materials tested are suitable for use at doses up to 10 kGy, which is the current internationally approved limit for irradiating foods. In some countries, packaging materials intended for irradiation are subject to approved lists (e.g. United States of America, Canada, United Kingdom). Such a list is also being developed by Poland. Clearly, the selection of suitable forms of packaging and packaging materials is also the responsibility of the food industry, in consultation with the food irradiator. FAO/IAEA is collecting information on approved packaging materials for food irradiation.

## Provisions for the labelling of irradiated foods

"Labelling" means the presentation of information on the label, in accompanying documents or displayed near the food. The "label", on the other hand, is the affixture of this information to the container. Labelling serves the purposes not only of the consumer, but also of food control authorities and traders. All countries, which have introduced regulations on food irradiation require the declaration of irradiation treatment of the food (see Annex 1). However, not all specify the exact expressions to be used.

The Codex Alimentarius Commission has made the following recommendations for the labelling of irradiated foods:

<u>Codex General Standard for Irradiated Foods</u> (CODEX STAN 106-1983)

"6. <u>LABELLING</u>

6.1. Inventory Control

For irradiated foods, whether prepackaged or not, the relevant shipping documents shall give appropriate information to identify the registered facility which has irradiated the food, the date(s) of treatment and lot identification.

6.2. Prepackaged food intended for direct consumption

The labelling of prepackaged irradiated foods shall be in accordance with the relevant provisions of the Codex General Standard for the Labelling of Prepackaged Foods.

6.3 Foods in bulk containers

The declaration of the fact or irradiation shall be made clear on the relevant shipping document."

<u>Codex General Standard for the Labelling of Prepackaged Foods</u>, CODEX STAN 1-1985, CODEX ALIMENTARIUS VOLUME VI, as amended by the 18th Session of the Codex Alimentarius Commission, 1991.

"5.2. Irradiated Foods

5.2.1. The label of a food which has been treated with ionizing radiation shall carry a written statement indicating that treatment in close proximity to the name of the food. The use of the international food irradiation symbol, as shown below is optional, but when it is used, it shall be in close proximity to the name of the food.

5.2.2. When an irradiated product is used as an ingredient in another food, this shall be so declared in the list of ingredients.

5.2.3. When a single ingredient product is prepared from a raw material which has been irradiated, the label of the product shall contain a statement indicating the treatment."

## Special considerations concerning labelling of irradiated foods

Statements on the label that a food product or an ingredient included in a composite food product has been irradiated may have either a positive or a negative impression on the consumer. This depends on a variety of factors, including lack of familiarity with food irradiation technology, and misinformation spread by activist groups which oppose food irradiation. The very word "irradiation" implies something negative to many people, including association with radioactive contamination. Thus, a product labelled as "irradiated", where the purpose of the treatment is not of interest directly to the consumer (e.g. quarantine treatment), will leave doubt in the mind of the consumer. This may also be the case where ingredients in a composite food or single ingredient processed foods mede from irradiated raw materials are labelled with reference to irradiation treatment. On the other hand, high quality out-of-season fruits, non-sprouting onions or potatoes, or hygienically safe irradiated meat products present a direct advantage to the consumer, who will learn to select such irradiated foods on the basis of appropriate labelling. In these cases, one can still argue, however, that the word "irradiated" or some similar expression is not very informative, unless the consumer is familiar with food irradiation technology. This does not appear to be the case as yet.

The expected movement of irradiated foods in the food chain is shown in Annex 2. As can be seen, the potential use of irradiated foods at various stages in the food chain cannot be covered easily by simple labelling provisions which will be meaningful for the consumer. The Codex Standard includes labelling provisions for most of the situations illustrated in Annex 2 and tends to be more detailed than the labelling provisions included in national regulations. It would be desirable to harmonize the labelling of irradiated foods in a way which is informative for the consumer and consistent with Codex principles and standards.

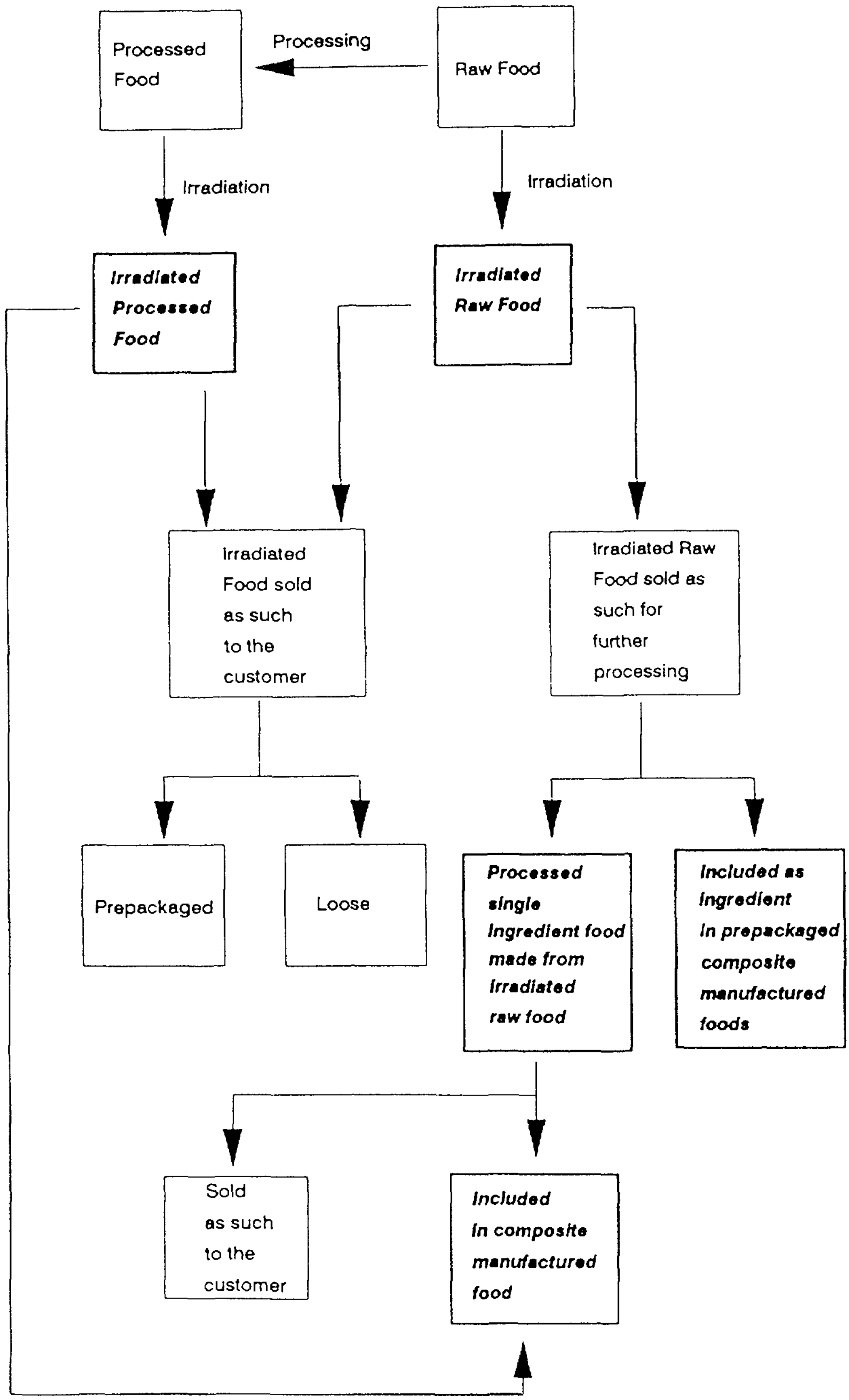
Annex 1

## SPECIFIC LABELLING REQUIREMENTS FOR PREPACKAGED IRRADIATED FOOD

| Country | Statement | Logo | Other | Ingredients |
|---|---|---|---|---|
| Argentina | "Food irradiated with ionizing radiation | Optional | Plant<br>Date<br>Batch | If > 10% |
| Austria | Declaration of the fact of irradiation | No provision | None | No provision |
| Belgium | Declaration of irradiation treatment with purpose, or "Treated by ionization" or "Treated by Co 60 gamma radiation" | Optional | Plant<br>Date<br>Batch | No provision |
| Brazil | "Food treated by irradiation process" | No provision | None | No provision |
| Canada | "Treated with radiation" or "Treated by irradiation" or "Irradiated" | Required | None | If > 10% |
| Cuba | Declaration of the fact of irradiation | No provision | None | No provision |
| Denmark | "Irradiated" or "Radiation preserved" or "Treated with ionizing radiation" or "Preserved by ionizing radiation" | No provision | None | "Irradiated" or "Contains irradiated " etc |
| Finland | "Processed by ionizing radiation" | No provision | None | If > 5% |
| France | "Irradiated" or "Treated by irradiation" | No provision | Plant | No provision |
| FRG | Declaration of the fact of irradiation | No provision | None | No provision |
| Indonesia | "Radura" | Required | Purpose<br>Plant<br>Date<br>State | No provision |
| Israel | "Food preserved by radiation" | Required | None | No provision |
| Italy | Declaration as approved | No provision | Plant | No provision |
| New Zealand | No provision | No provision | None | No provision |
| Singapore | "Treated with ionizing radiation" or "Irradiated" | No provision | None | No provision |
| South Africa | No provision | No provision | None | No provision |
| Spain | Declaration as approved | No provision | None | No provision |
| Sudan | No provision | No provision | None | No provision |
| Switzerland | Declaration as regards the vitamin content | No provision | None | No provision |
| Sweden | Prohibits irradiated food | | | No provision |
| Syria | "Treated by ionizing radiation" | No provision | None | No provision |
| Thailand | "Food irradiated for " | Required | Purpose<br>Plant<br>Date | No provision |
| UK | "Irradiated", "Treated with ionizing radiation" | No provision | | Yes |
| USA | "Treated with radiation" or "Treated by irradiation" | Required | None | No provision |
| Yugoslavia | Declaration of the fact of irradiation | No provision | Plant<br>Date | No provision |
| EEC | Irradiated' or Treated with ionizing radiation" | No provision | Plant<br>Batch | No provision |

Annex 2

IRRADIATED PRODUCTS IN THE FOOD CHAIN



# DETECTION METHODS FOR IRRADIATED FOODS — REVIEW OF CURRENT DEVELOPMENTS

T. HAYASHI
National Food Research Institute, Ministry of Agriculture, Forestry and Fisheries,
Ibaraki, Japan

## Abstract

### Need for detection methods for irradiated foods

Although the wholesomeness of irradiated foods has already been proven, it is necessary to control the process of irradiating foods and the trade of irradiated foods. The authorities always have to determine whether foods have been irradiated or not. Some consumers are not in favour of irradiated foods and want to preclude them from their diets. They have a right to make their own choice between unirradiated and irradiated foods. It is important that the traders know whether the foods they deal with have been treated with ionizing radiation or not. Food processors should also know whether the materials they process have been irradiated or not.

Thus, identification of irradiated foods is important for authorities, consumers, traders and the food industry. It is difficult to determine whether foods, without a label, have been irradiated or not, once they leave the irradiation plant. It is recommended that irradiated foods should be labelled with words or sentences indicating the treatment. Still, there is a need for reliable methods to detect irradiated foods as useful means to check compliance with and supplement labelling regulations.

### International collaboration

FAO/IAEA initiated the Coordinated Research Programme on Analytical Detection Methods for Irradiation Treatment of Foods (ADMIT) in 1990. ADMIT established five specialized research groups: ESR Group, Luminescence Group, Physical Group (except ESR and Luminescence), Chemical Group and Biological Group to facilitate collaboration on each method. The Community Bureau of Reference of the Commission of the European Communities (BCR) started another research project on the identification of irradiated foods. The ADMIT and BCR Group are expected to collaborate with each other in order to avoid duplication of effort and ensure comparability of results. The methods which have been reported to be promising are evaluated on an inter-laboratory basis in the projects, and useful and reliable methods and their analytical procedures will be recommended at the end of the projects.

### State of the art of detection methods

(i) <u>ESR</u>

Although most of the radicals formed in foods are labile and do not remain for a long period, radicals formed in rigid matrices such as bones, shells and seeds are stable enough to be detected several months after irradiation. ESR spectra of bones enable the detection of irradiated animal and poultry meats, frog legs and fish. ESR analysis of shells and cuticles enables identifying irradiated shellfish. Irradiated fruits can be detected by ESR analysis of seeds, stones and pips. Radiation treatment of some spices such as red pepper also can be detected by ESR. Measurement of ESR signal amplitude after additional irradiation of a food sample at different doses enables the estimation of radiation dose.

(ii) <u>Luminescence</u>

Both chemiluminescence and thermoluminescence are promising methods for identifying irradiated foods. Minerals contaminating foods are responsible for the enhanced level of thermoluminescence.

Measurement of thermoluminescence of minerals separated from foods resulted in better detection of irradiation treatment. Mineral analysis by thermoluminescence enables detection of radiation treatment of vegetables, fruits, grains and tubers and bulbs as well as spices and dehydrated vegetables.

(iii) Physical methods (except ESR and luminescence)

The degradation of polysaccharides, such as starch and pectin by irradiation, results in a lowered viscosity. The viscosity measurement has a potential as a method to detect irradiated spices and dehydrated vegetables.

The electrical impedance of potato tubers changes depending upon dose. The impedance ratio of 5kHz to 50kHz can identify irradiated potatoes.

Chemical changes in spices caused by irradiation can be detected by near infrared analysis. The second derivative of near infrared spectrum differentiates between unirradiated and irradiated spices such as pepper and paprika.

(iv) Chemical methods

Radiation-induced reactions of lipids form hydrocarbons with one carbon atom less than the original carboxylic acids and with two carbon atoms less and one extra double bond. The formation of the hydrocarbons can be a parameter for detecting irradiation of lipid-containing foods, especially beef, chicken and pork. Cyclobutanones are also formed from fatty acids by irradiation and can be used for detecting irradiated meats and poultry.

o-Tyrosine is formed from phenylalanine by irradiation depending upon dose and can be detected in irradiated chicken, pork, fish and shrimps.

(v) Biological methods

Microbiological flora is altered by irradiation. Combined use of the direct epifluorescent filter technique (DEFT) and the aerobic total count (APC) is useful as a technique for the first screening of the sample which should be subjected to other identification methods to confirm irradiation treatment.

Irradiation inhibits shooting of seeds in fruits, which can be used for identifying irradiated fruits. Observation of shooting of halved embryo resulted in a reliable method of detecting irradiated citrus fruits.

## Need for detection methods for irradiated foods

Food irradiation has now been cleared as an acceptable practice in approximately 36 countries and is practised in 23 countries. Around 550,000 tons per year of foods are irradiated in the world and the tonnage of irradiated foods and the number of countries where foods are irradiated on a commercial basis increases annually. Irradiated foods will be widely traded internationally as well as domestically in the near future.

Although the wholesomeness of irradiated foods has already been proven, it is necessary to control the process of irradiating foods and the trade of irradiated foods. Administrative control of food irradiation process and distribution of irradiated foods is executed by means of inspection, dosimetry and documentation by responsible authorities in each country. The authorities always have to determine whether foods have been irradiated or not. Some consumers are not in favour of irradiated foods and want to preclude them from their diets. They have a right to make their own choice between unirradiated and irradiated foods. It is important that the traders know whether the foods they deal with have been treated with radiation or not, in order to properly handle the foods and to provide consumers with what they want. Food processors should know whether the materials they process have been irradiated or not.

Thus, identification of irradiated foods is important for authorities, consumers, traders and the food industry. It is difficult to determine whether foods, without a label, have been irradiated or not once they leave the irradiation plant. It is recommended that irradiated foods should be labelled in order that everyone can identify irradiated foods. The Codex Committee on Food Labelling, in 1989, concluded that irradiated foods should be labelled with words or sentences indicating the treatment. Each country should prepare a provision for labelling in regulations on irradiated foods. However, to check compliance with labelling regulations, it is essential that reliable methods for the detection of irradiated foods are available.

**Criteria for the detection methods**

The methods to detect irradiated foods should fulfill the following requirements:

(1) The measured response is specific to irradiation; not observed in unirradiated foods and not induced by other processing and preservation methods.

(2) The measured parameters are stable throughout the shelf-life of the foods.

(3) The measured parameters are independent of conditions for irradiation, storage and cultivation.

(4) The methods are rapid, reproducible and repeatable.

(5) The methods are sensitive enought to detect the foods irradiated at the minimum practical dose.

(6) The methods are cheap and do not require any expensive instrument.

(7) The methods are easy to perform and do not demand high technology processes or complex data interpretation.

(8) The methods require a small sample size.

**Early development of detection methodologies**

Research activities on the detection of irradiated foods were extensively carried out in 1960s and early 1970s. The results of the studies on the identification of irradiated foods were discussed and evaluated at two conferences held in 1970 and 1973. At the two conferences, it was concluded that the development of methods to identify irradiated foods was difficult, because most of the changes in foods caused by irradiation were also brought about by other processing methods of foods such as heating, drying, freezing, etc. Interest in the development of detection methods of irradiated foods then waned for about 10 years.

The progress of food irradiation in 1980s re-established the importance of developing detection methods. Another conference on identification of irradiated foods was held in Neuhrenberg/Munich, Germany, in November 1986, and detection methods which had been studied were thoroughly reviewed. It was concluded that there was no established method for identifying irradiated foods but that considerable progress could be expected in the near future, because new concepts and ideas were suggested based on the development of technologies such as mechanics and electronics.

FAO/IAEA initiated the Co-ordinated Research Programme on Analytical Detection Methods for Irradiation Treatment of Foods (ADMIT) in 1990, in which scientists at 23 laboratories from 16 countries conducted collaborative studies for establishing detection methods of irradiated foods. ADMIT established five specialized research groups: ESR Group, Luminescence Group, Chemical Group, Physical Group (except ESR and Luminescence) and Biological Group to facilitate collaboration on each method. The Community Bureau of Reference of the Commission of the European Communities (BCR) started another research project on identification of irradiated foods. The ADMIT and BCR group are expected to collaborate with each other in order to avoid duplication of effort and ensure comparability of results. The methods which have been reported to be promising are evaluated on an inter-laboratory basis. Useful and reliable methods and their analytical procedures will be recommended at the end of the projects.

**State of the art of detection methods**

(i) ESR

ESR is widely used to detect radicals formed in foods by irradiation. Although most of the radicals formed in foods are labile and do not remain for a long period, radicals formed in rigid matrices such as bones, shells and seeds are stable enough to be detected several months after irradiation. ESR spectra of bones enable the detection of irradiated animal and poultry meats containing bones (Fig. 1). The radicals in bone are identical with that found in hydroxyapatites and independent of the origin of bone. Irradiated frog legs and fish are detected by ESR analysis of bone as well. ESR analysis of shells and cuticles enables identifying irradiated shellfish. Irradiated fruits can be detected by ESR analysis of seeds, stones and pips (Fig. 2). Radiation treatment of some spices such as red pepper also can be detected by ESR (Fig. 3).

ESR gives us information not only on whether or not foods have been irradiated but also on the dose applied to foods. Measurement of ESR signal amplitude after additional irradiation of an unknown food sample at different doses enables the estimation of radiation doses (Fig. 4).

(ii) Luminescence

Both chemiluminescence and thermoluminescence are promising methods for identifying irradiated foods (Fig. 5). In chemiluminescence, lights emitted by the reaction of luminol and oxidizing agents formed in irradiated foods are measured. In thermoluminescence, lights emitted from foods during heating at 400$^{o}$C to 500$^{o}$C are measured. The luminescence measurements enable identification of irradiated spices and dehydrated vegetables for more than one year after irradiation. Minerals contaminating foods are responsible for the enhanced level of thermoluminescence (Fig. 6). Measurement of thermoluminescence of minerals separated from foods resulted in better detection of irradiation treatment (Fig. 7). Mineral analysis by thermoluminescence enables detection of radiation treatment of vegetables, fruits, grains, tubers and bulbs as well as spices and dehydrated vegetables. Irradiated shelled shrimps can be identified by the luminescence methods as well.

(iii) Physical methods (except ESR and luminescence)

The degradation of polysaccharides such as starch and pectin by irradiation results in a lowered viscosity. The viscosity measurement has a potential as a method to detect irradiated spices and dehydrated vegetables (Fig. 8).

The electrical impedance of potato tubers changes depending upon dose. The impedance ratio at 5 kHz to 50 kHz can identify irradiated potatoes (Fig. 9)

Chemical changes in spices caused by irradiation can be detected by near infrared analysis. The second derivative of near infrared spectrum is used to differentiate between unirradiated and irradiated spices such as peppers and paprika (Fig. 10).

(iv) Chemical methods

Radiation-induced reactions of lipids form hydrocarbons with one carbon atom less than the original carboxylic acids and with two carbon atoms less and one extra double bond. The formation of the hydrocarbons is dependent upon dose and is not affected by the presence of air or moisture, heating, lipid oxidation and storage. This method can be applied to any lipid-containing foods, especially beef, chicken and pork (Fig. 11). Cyclobutanones are also formed from fatty acids by irradiation and can be used for detecting irradiated meats and poultry.

o-Tyrosine is formed from phenylalanine by irradiation depending upon dose and can be detected in irradiated chicken, pork, fish and shrimps (Fig. 12). The level of o-tyrosine in unirradiated meat is lower than 0.1 mg/kg, while that in the meat irradiated at 5 kGy at 20°C is 0.8 to 1.2 mg/kg and that in the meat irradiated at 5 kGy at -18°C is 0.5 to 0.8 mg/kg.

Irradiation of organic compounds forms various gases such as hydrogen and carbon monoxide. The analysis of hydrogen and carbon monoxide gases enables detection of irradiated peppers and shrimps. (Fig. 13).

(v) Biological methods

Combined use of the direct epifluorescent filter technique (DEFT) and the aerobic total count (APC) enables differentiation between unirradiated and irradiated spices (Table 1). However, bacterial floral of food is altered by any treatment for disinfection and the method can not discriminate irradiated foods from those treated by other techniques for decontamination. The DEFT-APC is useful as a technique for the first screening of the sample which should be subjected to other identification methods to confirm irradiation treatment.

Irradiation inhibit shooting of seeds in fruits, which can be used for identifying irradiated fruits. Observation of shooting of halved embryos resulted in a reliable detection of irradiated citrus fruits (Fig. 14).

**Conclusion**

Various methods for identifying irradiated foods have been proposed (Table 2). Most of the physical, chemical and biological changes in foods caused by irradiation are not unique to radiation treatment nor stable enough to be detected for a long period. Innternational collaboration, however, will result in several reliable methods for detecting irradiated foods. Especially ESR and luminescence analysis of inorganic components of foods will make it possible to detect irradiation treatment of various foods, because radicals formed in bones, shells, cuticles and minerals are extremely stable.

If the methods to identify irradiated foods are established, all irradiated foods will be in compliance with labelling regulations, which will facilitate the authoritative control and proper handling of irradiated foods and give consumers a tool with which they choose irradiated or unirradiated foods. Thus, the establishment of reliable methods for detecting irradiated foods will greatly contribute to the progress of practical food irradiation.

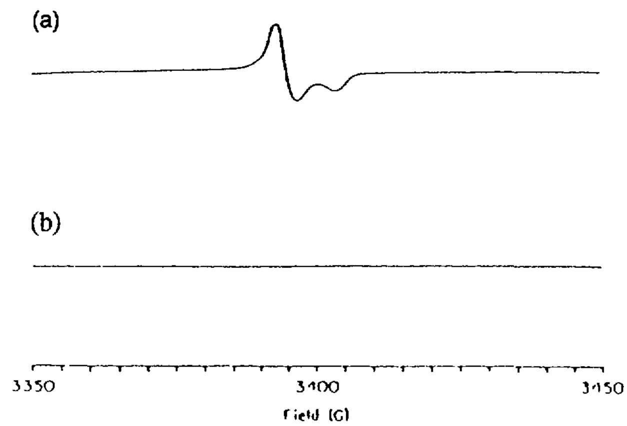



FIG. 1. X band ESR spectrum of (a) the signal in irradiated chicken bone with a gain setting of 1 × 10$^1$ (dose = 1 kGy) and (b) unirradiated chicken bone with a gain setting of 1 × 10$^1$.

*J.S. Lea et al., Int. J. Fd. Sci. Technol. 23 625 (1988).*

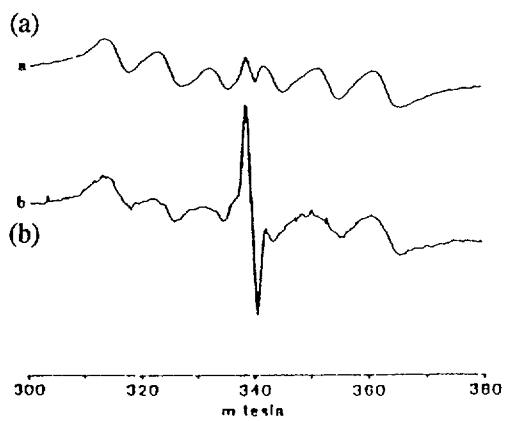



FIG. 2. ESR spectra of excised strawberry achenes (a) before and (b) after electron irradiation with a dose of 10 kGy. Modulation amplitude 1 mT. Spectra recorded with similar gain.

*K.J.F. Dodd et al., Radiat. Phys. Chem. 26 451 (1985).*

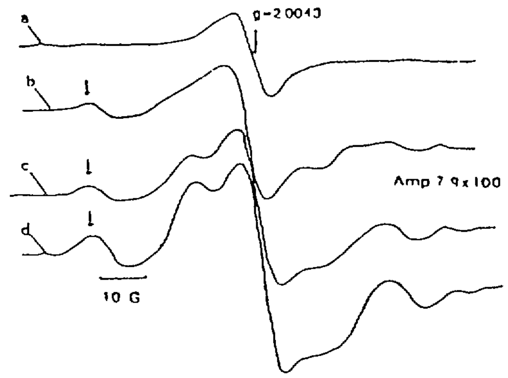



FIG. 3. ESR spectra of radicals produced in red pepper (RP) by $\gamma$-irradiation. a: intact; b: irradiated at 10 kGy; c: irradiated at 30 kGy: d: irradiated at 50 kGy. The arrows show the minor signal.

*Uchlyama, S., et al., J.Fd. Hyg. Soc. Jpn 31 499 (1990).*

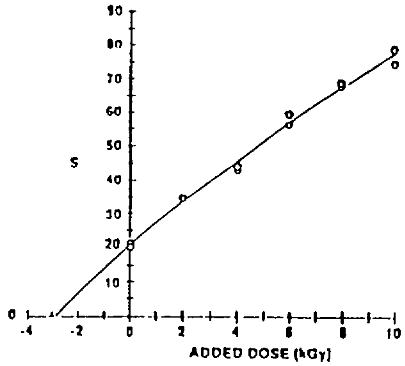



FIG. 4. A plot of the ESR signal amplitude, S, vs added absorbed dose in kGy. The curve is a polynomial least-squares fit to the data obtained for irradiated pork bones (initial dose of 3 kGy) as measured by the Manchester laboratory.

*Desroslers, M.F., et al., Int. J. Fd. Sci. Technol. 25 682 (1990).*

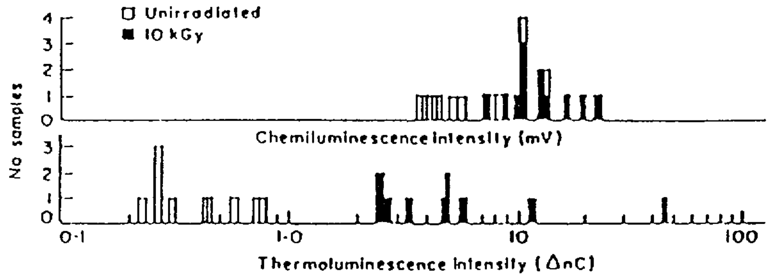



FIG. 5. Chemiluminescence and thermoluminescence intensity of unirradiated and irradiated black pepper from ten different companies measured immediately after irradiation.

*Helde, L., Boegl, W., Int. J. Fd. Sci. Technol. 22 93 (1987).*

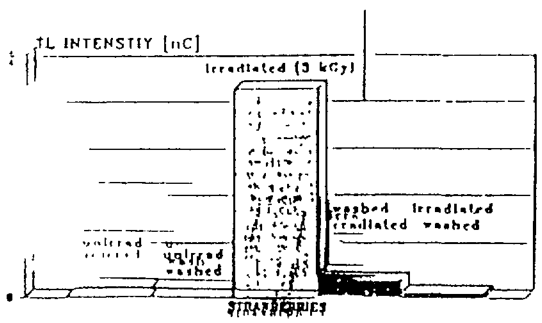



FIG. 6. TL intensity of unwashed and washed strawberries.

*Helde, L., et al., J. Agric. Fd. Chem. 38 2160 (1990).*

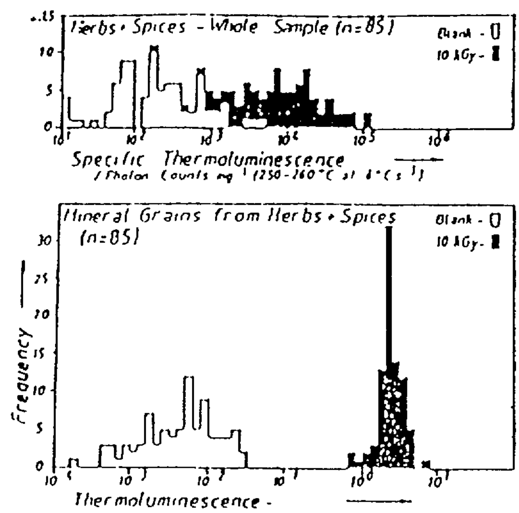



FIG. 7. The effect of mineral separation on TL discrimination between 85 irradiated samples and unirradiated blanks. Histograms of TL signals from whole samples (top) show considerable overlap whereas TL signals from mineral fractions, renormalised to the second glow response to a fixed gamma dose, result in unambiguous separation.

*Sanderson, D.C.W., et al., Radiat. Phys. Chem. 34 915 (1989).*

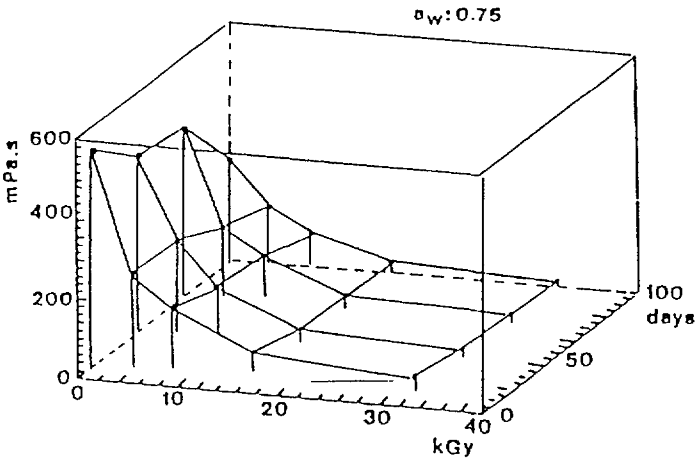



FIG. 8. Apparent viscosity of heat gelatinized 10% suspensions of ground black pepper at 0.75 $a_w$-level as affected by irradiation and post-irradiation storage. Temperature of viscosity measurement: 25°C, shear rate: 437.4 $s^{-1}$.

*Farkas, J., et al., Radiat. Phys. Chem. 35 324 (1990).*

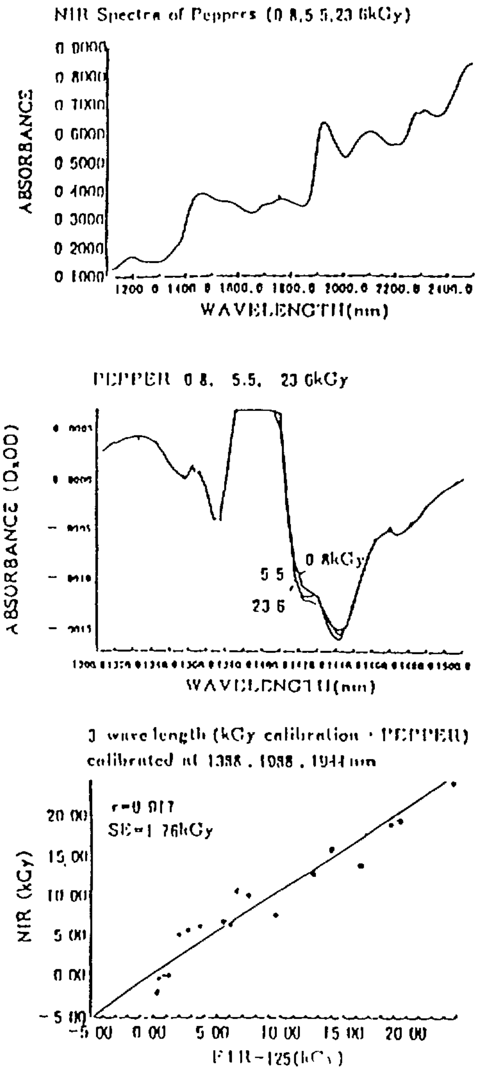



FIG. 10. NIR spectrum of irradiated pepper.

*Suzuki, T., et al., Fd. Irrad. Jap. 23 77 (1988).*

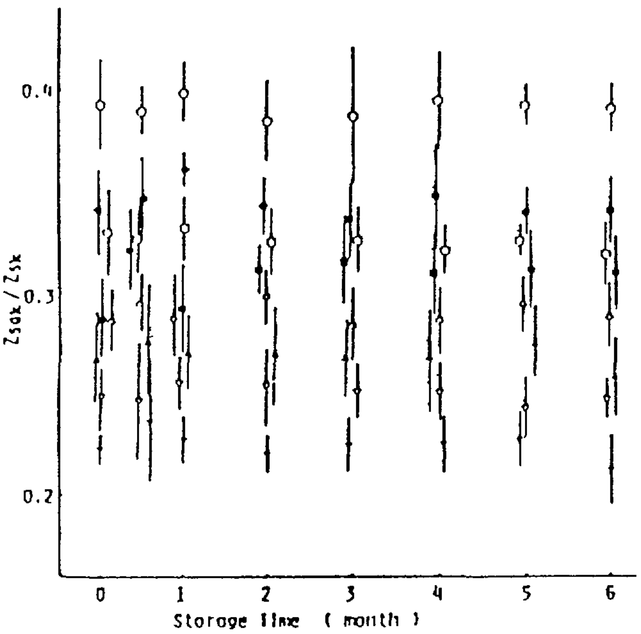



FIG. 9. Identification parameter, $Z_{50k}/Z_{5k}$, for the potatoes stored at 5°C.

o: 0 Gy; •: 50 Gy; □: 100 Gy; ■: 150 Gy; ▵: 200 Gy; ▴: 300 Gy; ▿: 500 Gy; ▾: 1000 Gy.

*Hayachi, T., et al., Agric. Biol. Chem. 46 905 (1982).*

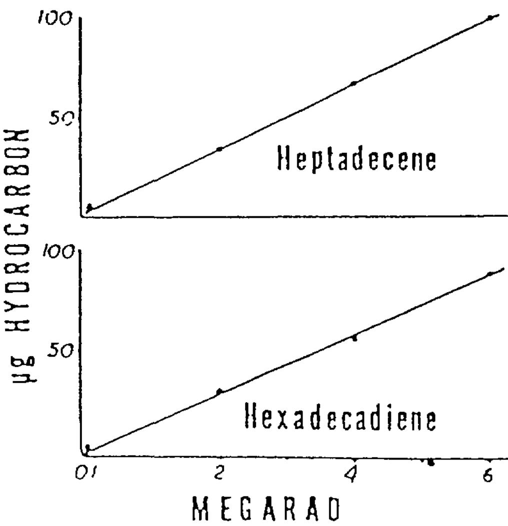



FIG. 11. The effect of irradiation dose on the production of hexadecadiene and heptadecene in pork meat irradiated at 25°C.

*Nawar, W.W., Balboni, J.J., J.A.O.A.C. 53 726 (1970).*

Table 1 The microbial counts of spice samples non irradiated and irradiated with a dose of 5 kGy and 10 kGy obtained using the direct epifluorescent filter technique (DEFT) and the aerobic plate count (APC) method

| Sample No | Material | Quality | Irradiation Dose (kGy) | Log DEFT (count/g) | Log APC | Difference (log DEFT log APC) |
|---|---|---|---|---|---|---|
| 1 | All spice | Whole | 0 | 6 85 | 4 91 | 1 94 |
| | | | 5 | 6 76 | 1 90 | 4 86 |
| | | | 10 | 6 94 | ND | 6 94 |
| 2 | Basil | Cut | 0 | 6 93 | 4 98 | 1 95 |
| | | | 5 | 6 47 | 2 31 | 4 16 |
| | | | 10 | 6 40 | 0 70 | 5 70 |
| 3 | Black pepper | Whole | 0 | 8 05 | 6 54 | 1 51 |
| | | | 5 | 7 81 | 3 68 | 4 13 |
| | | | 10 | 7 80 | 1 40 | 6 40 |
| 4 | Black pepper | Crushed | 0 | 7 18 | 4 62 | 2.56 |
| | | | 5 | 7 15 | 0 70 | 6 45 |
| | | | 10 | 7.36 | 0 70 | 6 66 |
| 5 | Black pepper | Powder | 0 | 8 08 | 7 41 | 0 67 |
| | | | 5 | 8 36 | 4 22 | 4 14 |
| | | | 10 | 8 48 | 1 70 | 6 78 |
| 6 | Cardamom | Whole | 0 | 6 22 | 3 06 | 3 16 |
| | | | 5 | 6 34 | ND | 6 34 |
| | | | 10 | 6 17 | ND | 6 17 |
| 7 | Cardamom | Crushed | 0 | 6 97 | 3 56 | 3 41 |
| | | | 5 | 7 46 | 2 26 | 5 20 |
| | | | 10 | 7.33 | ND | 7 33 |
| 8 | Cinnamon | Bar | 0 | 5 62 | 2 23 | 3 39 |
| | | | 5 | 6 81 | ND | 6 81 |
| | | | 10 | 6 86 | ND | 6 86 |
| 9 | Cinnamon | Crushed | 0 | 5 84 | 7 62 | 3 22 |
| | | | 5 | 5 79 | 1 87 | 3 92 |
| | | | 10 | 6 01 | ND | 6 01 |
| 10 | Cinnamon | Powder | 0 | ND | 2 18 | |
| | | | 5 | ND | ND | |
| | | | 10 | ND | ND | |
| 11 | Ginger | Whole | 0 | ND | 2 00 | |
| | | | 5 | ND | ND | |
| | | | 10 | ND | ND | |
| 12 | Garlic | Powder | 0 | ND | 3 63 | |
| | | | 5 | ND | ND | |
| | | | 10 | ND | ND | |
| 13 | Marjoram | Cut | 0 | 6 23 | 4 51 | 1 72 |
| | | | 5 | 6 30 | 2 22 | 4 08 |
| | | | 10 | 6 44 | ND | 6 44 |
| 14 | Marjoram | Powder | 0 | ND | 4 63 | |
| | | | 5 | ND | 2.57 | - |
| | | | 10 | ND | ND | |
| 15 | Oregano | Cut | 0 | ND | 2 80 | - |
| | | | 5 | ND | 1 00 | |
| | | | 10 | ND | ND | |
| 16 | Paprika | Powder | 0 | 7 40 | 4 28 | 3 13 |
| | | | 5 | 7 47 | 1 00 | 6 47 |
| | | | 10 | 7.50 | ND | 7.50 |
| 17 | Thyme | Cut | 0 | 6 91 | 5 46 | 1 45 |
| | | | 5 | 6.52 | 2 06 | 4 46 |
| | | | 10 | 7 05 | 1 00 | 6 05 |
| 18 | White pepper | Whole | 0 | 6 03 | 3 25 | 2 78 |
| | | | 5 | 6 14 | 1 00 | 5 14 |
| | | | 10 | 6 04 | ND | 6 04 |
| 19 | White pepper | Whole | 0 | 6 57 | 3 61 | 2 96 |
| | | | 5 | 6 48 | 1 09 | 5 39 |
| | | | 10 | 6 29 | ND | 6 29 |
| 20 | White pepper | Powder | 0 | 5 70 | 3 88 | 1 82 |
| | | | 5 | 5 67 | 1 30 | 4 37 |
| | | | 10 | 5 78 | ND | 5 78 |

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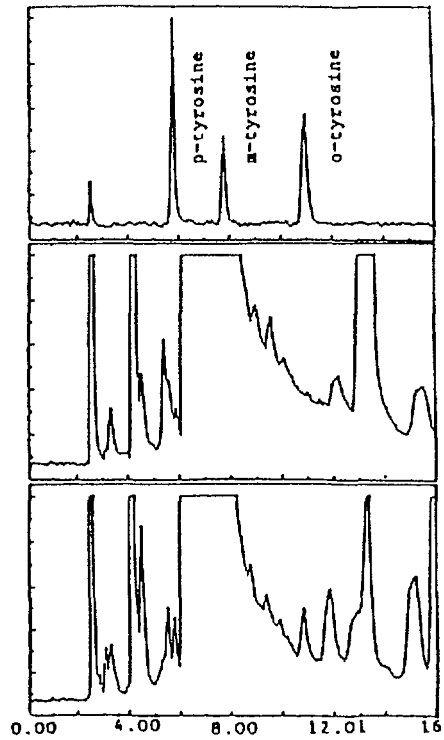


FIG. 12. High performance liquid chromatography of o-tyrosine (conditions see text). Standard solution; unirradiated chicken; irradiated chicken, 2.5 kGy.

*Meier, W., et al., Radiat. Phys. Chem. 35 332 (1990).*

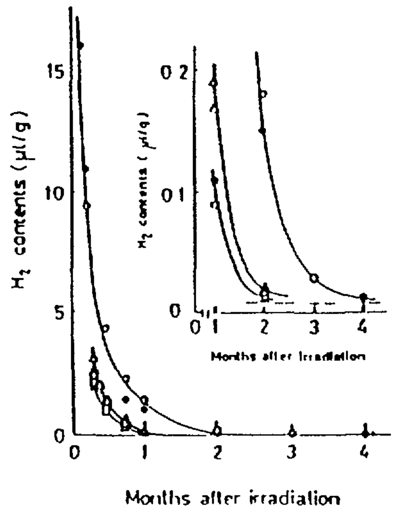


FIG. 13. The $H_2$ content ($\mu l$) in 1 g of black (solid symbols) or white (open symbols) pepper as a function of time (months) after 10 kGy irradiation. The storage temperatures were 7 (circles), 22 (triangles) and 30°C (squares). The lower limit of detection of $H_2$ (0.0080 $\mu l/g$) is indicated by a dotted line in the inset, where the scale for $H_2$ is enlarged 50 times. Dots were substituted for solid circles when located very close to open circles.

*Dohmaru, T., et al., Radiat. Res. 120 552 (1989).*

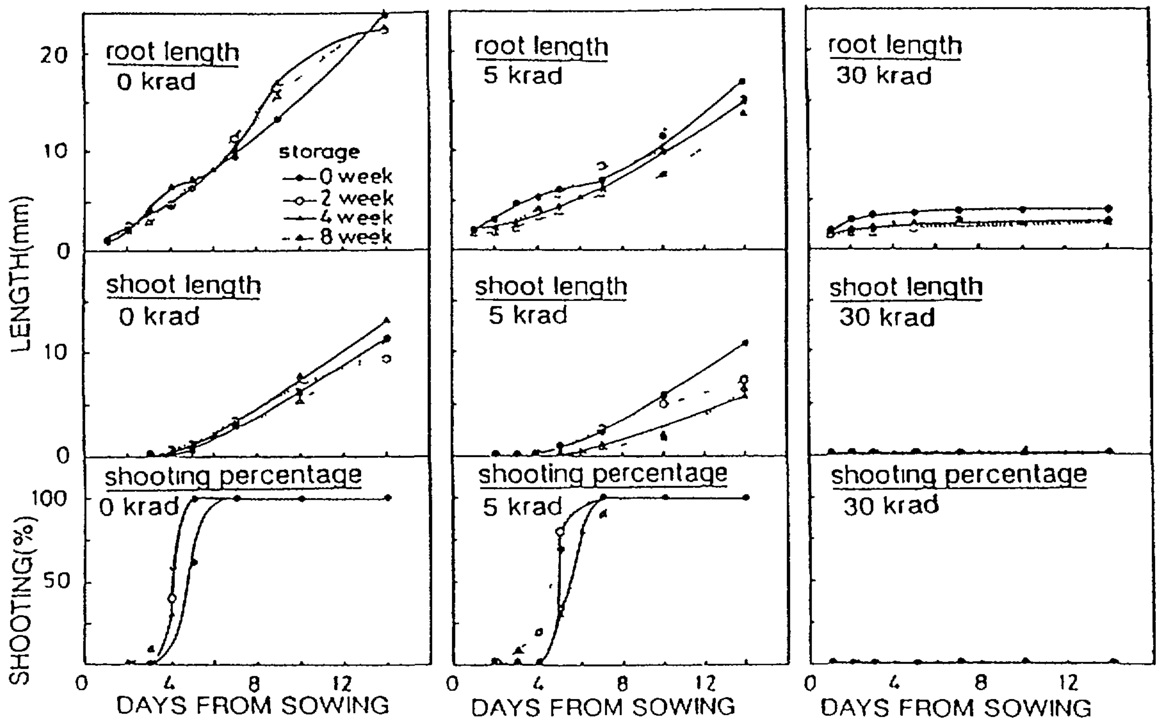


FIG. 14 Effect of storage period on growth curve of half-embryo extracted from ripe grapefruit var Marsh White from California, stored at 10°C in carton

*Kawamura, Y, et al, J Fd Sci 54 379 (1989)*

Table 2 Summary of methods for detecting irradiated foods

| | Physical | Chemical | Biological |
|---|---|---|---|
| Spices, herbs, etc | ESR, Luminescence, NIR, Viscosity | Gas | DEFT APC (Flora) |
| Potato | Luminescence, Impedance | Cell wall change | PAL, Chlorogenic acid Wound healing |
| Onion | Luminescence, Adhesion of epidermis | | Rooting |
| Cereals | Luminescence, DSC Viscosity | Malonaldehyde Deoxy compounds | Rooting Germination |
| Fruits & Vegetables | ESR, Luminescence Rheology of cell wall | Carbonyl compound | Microbial flora Rooting of seed |
| Meat & Poultry | ESR, MW of protein | Lipid derivatives o Tyrosine, Gas, Mucleic acids | Peroxidase Protease |
| Fish, shellfish, etc. | ESR, Luminescence MW of protein, IR Impedance | Gas | Microbial flora |
| Mushroom | ESR | | Pigment formation Mycelium formation |

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# NEED FOR A UNIFORM SYSTEM OF CONTROL FOR ENSURING ACCEPTANCE OF IRRADIATED FOOD IN TRADE

N. TAPE
Ottawa, Canada

## Abstract

As national and international trade in food increases, and as markets become more knowledgeable and demanding, all food preservation techniques must be applied in a consistent, uniform manner using recognized systems of control. Such systems are particularly relevant to irradiation since inspection of the final product cannot reveal previous handling or the treatment applied. Several UN agencies provide governments with food control assistance. FAO has a major programme to provide assistance and training on food laws and regulations, on food laboratories and inspection systems, on monitoring of contaminants, and on the formulation of national strategies for the control of food quality. Other agencies have specialized programmes relating to their primary interest. For example, the WHO focuses on food safety, both chemical and microbiological. It also promotes processes, such as irradiation which can make a contribution to primary health care. The IAEA has training and support programmes for the appropriate use of nuclear techniques in food and agriculture. Together, the three agencies support the work of the International Consultative Group on Food Irradiation (ICGFI) which provides codes of Good Irradiation Practice, guidelines, training courses and inventories of use to regulators and industry. The key areas for control in food irradiation facilities are the design, construction and operation of the facility; personnel training; raw materials; product processing, including packaging materials; record maintenance; and the environmental impact of the overall operation.

In order to obtain acceptance in trade of any processed food, whether treated by traditional canning procedures or by ionizing radiation, the use of uniform, consistently applied systems of control are required. Such controls are particularly relevant to irradiated food since inspection of the final product cannot reveal previous handling or treatment. More specifically, after treatment detection is not possible regarding:

(a) the microbiological condition of raw materials used; and

(b) the absorbed dose and its distribution uniformity in the product.

In addition, although some tests are emerging which can detect treatment of ionizing radiation in some foods (e.g. poultry and spices), a simple, general test is not available. It is unlikely that a simple, general purpose test will ever be available.

The people primarily interested in the control systems are, of course, government regulators, buyers of the product (wholesalers, retailers, importers, exporters) and consumers. While the control systems are essentially the same for any processed food, the fact that irradiation is a new commercial technology, draws considerable attention and, therefore, demands that owners and operators of irradiation facilities pay particular attention to control systems. Market forces and regulatory agencies will require the application of specific control measures in order to market irradiated foods nationally or internationally. These control measures should be applied in an open, documented manner. Without such an approach, acceptance of irradiated food in trade is at risk.

### Food control assistance

Several United Nations (UN) agencies provide assistance to governments wishing to establish or improve food legislation, regulations, laboratories and inspection systems. This assistance includes the safety, nutrition, quality, packaging and cost/benefit aspects of food control. The Food and Agriculture Organization (FAO) has assistance and training programmes on establishing or updating of food laws and regulations, food laboratories and inspection systems, monitoring of contaminants, and the formulation of national strategies for the control of food quality and human resource development. The World Health Organization (WHO) has complementary programmes and training assistance focused on food safety. The Codex Alimentarius Commission has elaborated and adopted over 220 food standards and 35 codes of practice, including a specific standard and code for irradiated foods and irradiation facilities. The International Atomic Energy Agency (IAEA) and the International Consultative Group on Food Irradiation (ICGFI) have training programmes, codes of practice and information documents specifically on food irradiation. WHO also provides considerable information and collaborates with other agencies in organizing and conducting training programmes. WHO has taken a very positive position on the utility of food irradiation as a preservation technique to improve food safety and global food supplies.

**Key controls**

Let us now focus on the key areas of control in a food irradiator plant. They are as follows:

- design, construction, and operation of the facility
- personnel training
- raw materials
- product processing, including packaging materials
- record maintenance
- environmental impact of the overall operation

(i) Irradiation facility

National governments normally require licensing to acquire and operate irradiators. Information must be submitted in an application according to national government guidelines and in sufficient detail to permit an independent assessment of the hazards and the related precautions taken to protect both operators and the public. The application is normally submitted in advance of the proposed start of constructions, since review of the application may result in changes to the design of the facility.

The application should include the following information:

(a) proposed use of the irradiator and its estimated hours of operation;

(b) source of ionizing energy - e.g. radionuclides or accelerated electrons;

(c) irradiator construction and operation, including construction materials;

(d) shielding design and materials;

(e) calculated radiation levels for all areas in the vicinity of the irradiation chamber;

(f) interlocks, indicators, and warning systems;

(g) operating procedures;

(h) training manuals for personnel;

(i) irradiator operation quality assurance requirements;

(j) records of their maintenance;

(k) emergency procedures;

(l) source loading, replacement and removal procedures; and

(m) seismic analysis in order to confirm that the shielding will withstand any displacement which may occur due to ground movement.

(ii) Trained personnel

Staff training is a basic requirement in any operation, whether in a manufacturing plant, quality assurance laboratory, or in office work. Training is required not only to assure production efficiency and consistent output of high quality products, but also to establish safe working conditions, meet environmental requirements (e.g. noise) and to enhance employee career development.

An irradiator plant is primarily a combination of an irradiation chamber, a warehouse, a laboratory and an office. All employees, whether in the plant, laboratory or office, should have a basic knowledge of the irradiation process, classification and description of types of irradiators, radiation safety philosophy, irradiator design requirements, regulatory control, safety systems, emergency response plans, as well as the more traditional occupational safety and health issues, such as working conditions, fire control and escape procedures.

Well informed staff will also aid in community public relations by informing their friends and the general public of the plant and its products. Community relations would also be enhanced by holding special information sessions and plant tours for the media, professional associations, and the general public. The owners and management of irradiator facilities have found by experience the vital importance of careful preparation in introducing irradiation plants to a community. Establishing and maintaining good relations with regulatory authorities, customers and the general public is a key factor for the acceptance of irradiated foods. Knowledgeable staff can play an important role in building these relations.

Plant operators and laboratory staff require more extensive training on radiation preservation of foods, government regulations and the operation of food irradiation facilities, with particular attention to radiation characteristics, dose distribution in the product, packaging materials, and irradiator design and operation. This specialized training is described elsewhere in this seminar proceedings. Training courses to certify plant operators and inspectors have been developed in several countries, as well as by ICGFI.

(iii) Raw materials

One of the basic tenets in achieving high quality food products is to start with good quality raw materials. Good quality materials and good manufacturing practices (GMPs) equate to high quality products. No preservation process can improve the condition of a deteriorated food. However, the fact that some traditional technologies (such as pasteurization) and irradiation treatment could be misused to clean up "dirty" food, is a cause for concern. This is particularly true for the relatively new process of food irradiation which leaves the food almost unchanged and is essentially undetectable.

General principles of food hygiene are applied to define the selection and handling of raw materials for food processing. The Codex Alimentarius Commission (Codex) adopted a Code of Practice on "General Principles of Food Hygiene". This Code is used in many countries for food production intended for the domestic and export markets. Commodity specific codes of hygiene have also been adopted by Codex. These codes, along with ICGFI codes of Good Irradiation Practice, help plant management to determine the "quality" of their raw materials.

With regard to the parameters of "quality" for raw materials for processing, there has been a long standing need for microbiological criteria. These criteria would, of course, apply to all types of food processing, whether it be freezing, refrigeration, pasteurization, irradiation or any other process. To this end, ICGFI held a consultation in 1989 on "Microbiological Criteria for Foods to be Processed, including by Irradiation". The experts concluded that microbiological criteria for raw materials should be introduced, whenever possible, to give additional assurance of GMPs. It also recommended that the Hazard Analysis Critical Control Point (HACCP) concept should be applied to food manufacturing in order to give added assurance of adherence to GMPs. Provisional guidelines were suggested for some products, such as spices, herbs and vegetable seasonings. However, inadequate data were available on which to base guidelines for several other products such as mechanically separated meat, or frogs' legs. The experts stressed that this data should be gathered in order that suitable microbiological criteria could be elaborated.

(iv) Product processing

In most countries, a government regulatory authority, such as the Department of Agriculture, requires compliance with several protocols for a facility to irradiate a food product, particularly poultry and meat products. Protocols are normally required for:

(a) facility approval - to justify that the irradiation facility is designed, constructed and operated for handling of the intended product

(b) quality control procedures - to describe the good manufacturing practices to be followed in producing the intended product and,

(c) product labelling - to meet all requirements for trade and commerce, perhaps including the irradiation logo and descriptive words to indicate why the product was irradiated.

To assist manufacturers meet the requirements of these protocols, Codes of Good Irradiation Practice (GIPs) have been developed by ICGFI. These documents were published in 1991. The nature and value of these codes is the subject of a subsequent presentation in this seminar (Session VI).

In summary, quality assurance procedures should be applied to irradiated foods in order to ensure that they have been treated appropriately to achieve the intended result and that all product quality has been maintained from raw material to finished product.

(v) Record maintenance

National regulations on food irradiation, as well as establishing radiation levels on products approved for such treatment, normally require that irradiator plant records be maintained for a minimum period of two years after treatment. Since there's no standard laboratory test to detect irradiated foods, record maintenance is mandatory in order to facilitate the tracing of the handling and treatment history of irradiated food products.

(vi) Environmental impact

By the end of 1990, there were more than 140 gamma irradiation plants operating in 43 countries. The majority of these plants are sterilizing medical products using gamma irradiation, principally from Cobalt 60. When not in use, the source, Cobalt 60, is stored in a deep water storage pool located directly below the concrete irradiation chamber. The water acts as a shield against the emitted gamma rays and enables immediate access by personnel into the radiation chamber. Testing mechanisms enable the source to be raised into the chamber or lowered into the pool as required. The activity of the radioactive material diminishes progressively. After an initial cobalt loading, replenishment by the supplier on a yearly basis is the usual requirement.

An irradiator facility loaded with 1 million to 5 million curries of Cobalt 60 will have the following factors to consider:

(a) Land and Water: The water in the stainless steel lined pool is confined to a closed loop system. It is kept clean and pure by circulating continuously through a de-ionizer having disposable cartridges. The latter are exchanged periodically by returning to the supplier for recycling. The water is not disposed into the ground or a drainage system; it is used only as a shield against radiation. The water itself does not become radioactive.

(b) Air: Ozone is a toxic and irritant gas produced in the irradiator chamber when the source is exposed to oxygen in the air. The ventilation system in the irradiator cell will exhaust the ozone into the atmosphere at a level complying with national regulations. The irradiation chamber is ventilated to reduce the ozone concentration to a permissible level prior to operator entrance.

(c) Radiation: Gamma radiation is confined to the irradiator cell only. Radiation levels outside the irradiator chamber are maintained at background. Safety locks installed in the irradiator prevent operators from entering the irradiator cell when the irradiator is operating.

(d) Transportation and Cobalt Loading: Cobalt 60 sources are transported to plants once a year in lead shielded containers. They are loaded and unloaded by trained supplier technicians. Transport packages are licensed by an Atomic Energy Control Board. Cobalt sources are returned to the supplier after their useful life expires.

(e) Safety: Employees should be trained according to their responsibilities. Training courses are available from suppliers, national governments and international agencies.

(f) Irradiator Equipment: The irradiator will have traditional electrical and mechanical equipment similar to that in small industrial factories having conveyers and moving parts.

The overall environmental effects of the facility are similar to the effects of a warehouse. Issues such as traffic, noise, land use, economy, etc. are particular to a facility and should be addressed by management.

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# FOOD IRRADIATION TECHNOLOGY IN ASIA AND THE PACIFIC — CURRENT STATUS OF APPLICATION AND REGULATORY CONTROL

(Session V)

**Chairman**

**A. HAZZARD**
WHO Regional Centre for the Promotion of Environmental Planning and Applied Studies (PEPAS)

# QUARANTINE TREATMENT OF FRESH FRUITS USING IRRADIATION — RECENT DEVELOPMENT IN MARKET POTENTIAL AND FUTURE PROSPECTS FOR ASIA AND THE PACIFIC

P. LOAHARANU
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture,
International Atomic Energy Agency, Vienna

## Abstract

Agricultural exports, including tropical fruits, vegetables and cut-flowers, are important sources of foreign exchange for many developing countries in Asia and the Pacific. These horticultural commodities from countries endemic with quarantine pests, especially fruit fly of the *Tephritidae* family, have to be treated to satisfy strict regulations on plant protection and quarantine in major importing countries, e.g. Australia, Japan, and the United States of America (USA). The prohibition of ethylene dibromide (EDB) as a food fumigant by the US Environmental Protection Agency in 1984 followed by Japan's Ministry of Agriculture, Forestry and Fisheries in 1987, have jeopardized trade in fresh fruits and vegetables originating from tropical and sub-tropical countries. Alternative treatments to satisfy quarantine regulations such as vapour and dry heat treatment, chilling, fumigation by methyl bromide, phosphine, and cyanide are commodity specific and have been used with limited degree of success. Irradiation by gamma rays has been demonstrated as a viable alternative to a wide variety of fruits and vegetables. The USDA Animal Plant Health Inspection Service (APHIS) has accepted irradiation as a quarantine treatment against various species of fruit fly infesting Hawaiian papaya in early 1989. The North American Plant Protection Organization (NAPPO) which includes Canada, Mexico and the USA has also accepted irradiation as a quarantine treatment of fresh fruits and vegetables in late 1989. A review will be made on the status of research and development on irradiation as a quarantine treatment especially as viable method to overcome trade barriers on tropical fruits. Research carried out under the sponsorship of FAO and IAEA in the past five years demonstrated that a minimum radiation dose of 150 Gy is effective to disinfest fruits and vegetables against all species of fruit fly tested without affecting the quality of host commodities. A minimum dose of 300 Gy is effective against mango seed weevil, mites and other insects which are subject to quarantine restrictions in certain importing countries. An international protocol to demonstrate the efficacy of irradiation as a quarantine treatment on a practical scale will be described.

There is increasing demand for consumption of fresh fruits and vegetables, especially in Western countries. For example, the USA's import of these commodities alone in 1987 amounted to approximately 6 million metric tonnes at a value of over US$2 billion. Recent trends show that consumers desire more fresh or fresh-like products that are visually appealing, full-flavoured, nutritious, convenient to prepare and serve, pesticide-free, and available throughout the year at reasonable prices (IFT, 1990). Thus, agricultural exports, including fresh fruits and vegetables, are important sources of foreign exchange for many developing countries. As the population in Western countries become more cosmopolitan and well-travelled, there will be an increasing demand for exotic agricultural products, particularly tropical fruits. However, with the exception of banana and pineapple, other tropical fruits have not been as successful in gaining wide access into markets of most Western countries.

Tropical fruits* normally have limited shelf-life, are susceptible to infestation by

* Tropical fruits are those that are cultivated in areas between the Tropic of Cancer and the Tropic of Capricorn, and/or in areas with similar natural climatic conditions (Codex Alimentarius Commission. ALINORM 89/35, Part I, 1989)

insect species which may be quarantined in some importing countries, sensitive to low temperatures which could slow down rate of senescence, and require rather delicate handling and packaging to maintain their premium quality. Hence, export of tropical fruits to Western markets is usually done by air which results in additional costs to the product.

While other factors impeding export of tropical fruits are also important, this paper will attempt to address a major problem facing trade in tropical fruits in certain importing countries, i.e. quarantine restrictions against insects especially fruit fly of the *Tephriditae* family.

**Quarantine restrictions**

A number of major importing countries of fresh fruits and vegetables (e.g. Australia, Japan and the USA) have strict regulations on plant protection and quarantine. These countries require that fresh commodities from countries endemic with quarantined pests, especially fruit fly of the *Tephriditae* family, be treated to ensure that such pests cannot be established in their territories. In the past, ethylene dibromide (EDB) was widely used for fumigation of such produce prior to importation. The prohibition of EDB by the US Environmental Protection Agency (EPA) in 1984 followed by the Japan's Ministry of Agriculture in 1987, and the restricted use of this chemical by other countries, has jeopardized trade in fresh fruits and vegetables originating from tropical and semi-tropical countries. Alternative treatments to EDB fumigation such as vapour and dry heat treatment, hot water dips, refrigeration at near 0°C for specific duration, and other chemicals such as methyl bromide, phosphine and cyanide, are commodity specific and have been used with varying degrees of success.

The ban on EDB has already created adverse impact on countries in Latin America and the Caribbean. For example, Mexico lost a significant proportion of exportation of mangoes (40,000 tonnes/annum) to the USA. Other Latin American and Caribbean countries are facing severe restrictions on their export of fresh produce to the USA. The present use of hot water treatment of mangoes in Mexico and some Caribbean countries to satisfy quarantine regulation in the USA has not helped to recover the market loss for this commodity.

**Commodity treatments to satisfy quarantine regulations**

The effectiveness of various conventional commodity treatments was reviewed by Sharp (1991). These treatments include the following:

(a) Fumigation. This is the act of releasing and dispersing a toxic chemical so that it reaches the pest organism wholly or primarily in the gaseous or vapour state. Methyl bromide is the principal fumigant used for the post-harvest treatment of many food and non-food commodities.

(b) Temperature manipulation. Temperature manipulation includes the use of heat and cold. The factors that must be considered in temperature manipulation are: (1) the effective time and temperature needed to kill the pest (efficacy), and (2) the tolerance of the commodity that is treated (phytotoxicity). Examples of temperature manipulation include heated water, heated air, vapour heat, and refrigeration.

(c) Modified / Controlled Atmospheres. Atmospheres are modified by either lowering the level of oxygen, raising the level of carbon dioxide, or by a concentration of altered levels of the gases. Modified atmosphere have been used to control insects in store grains and nut crops and to extend the storage life of apples, pears and strawberries. Insect species and each treated commodity vary in their response to a particular modified atmosphere.

(d) Insecticide dips. Post-harvest dips using dimethoate or fenthion are accepted quarantine treatments against insects from Australia infesting tomatoes and cucurbits. Residue data should be included with the data that establish the treatment.

In addition, multiple/combination treatments involving two or more treatments mentioned above can be used to provide quarantine security. Examples are methyl bromide fumigation followed by refrigeration, or vice versa.

Another approach to satisfy quarantine regulation is the elimination of the need for a treatment. Such approach could be done provided data indicate that:

(a) The commodity is resistant and no infestation is found.

(b) The commodity is a non-host at harvest time.

(c) The quarantine pest does not infest fruits because the population is not present during all or part of the year.

(d) The quarantine pest can be eliminated from a geographical area.

(e) Inspection at origin can be accepted in lieu of a treatment.

The use of irradiation as a quarantine treatment of fruits and vegetables was originally proposed by Koidsumi (1930) some 60 years ago. Later, Balock et al (1956) proposed that gamma rays from Co-60 be used as a commodity treatment for the oriental fruit fly. Research in Hawaii has shown that doses of 1,000 Gy or more may be required to prevent hatch of irradiated eggs, molting of treated larvae to the next instar or pupation of treated mature larvae. However, emergence of adults could be reduced or prevented by exposure of eggs, larvae, or 1 to 3-day-old pupae to less than 150 Gy. In the event that an adult did survive a low dose irradiation treatment, it would not be able to produce fertile offspring and the species would not be able to perpetuate itself. It has been proposed that the criterion for efficacy of irradiation as a quarantine treatment should be based on preventing adult emergence or on the inability of the species to perpetuate itself (Burditt, 1991).

Data on the use of irradiation as a quarantine treatment of fruits and vegetables were first evaluated by an international group of experts convened by FAO and IAEA in 1970 (IAEA, 1971). In 1986, an international Task Force on Irradiation as a Quarantine Treatment was convened by the International Consultative Group on Food Irradiation (ICGFI), a co-operative programme on food irradiation established under the aegis of FAO, IAEA and WHO since 1984. The Task Force evaluated available data on radiation sensitivity of various developmental stages of fruit fly of *Tephriditae* family, other insects and tolerance of host commodities treated. On the basis of the data, the Task Force recommended a minimum effective dose of 0.15 kGy to control infestation of fruit fly of *Tephriditae* family and 0.3 kGy to control infestation of other insects including mango seed weevil (ICGFI, 1986). Such recommended doses do not adversely affect the quality of most fruits and vegetables.

Data on radiation sensitivity of additional fruit fly species, other insects and mites have been generated under the FAO/IAEA Co-ordinated Research Programme on the Use of Irradiation as a Quarantine Treatment of Food and Agricultural Commodities, conducted in the past five years. These data together with those on the use of conventional quarantine treatments were evaluated by the second Task Force on Irradiation as a Quarantine Treatment of Fresh Fruits and Vegetables, Bethesda, Maryland, in January 1991 (Table 1). The data showed that a minimum dose of 150 Gy can be effectively used to disinfest fresh fruits and vegetables from eggs and larvae of major species of fruit fly (Table 2). A minimum dose of 300 Gy can be used to diinfest these fresh commodities from other insects and mites to prevent them from being established in non-infested areas (Table 3). Unlike other quarantine treatments which are either commodity or pest specific, irradiation is an effective broad spectrum disinfestation treatment against many species of fruit fly and other insect pests without adversely affecting the quality of most bost commodities (ICFGI, 1991).

**Approval of irradiated fresh fruits**

Although the Codex Alimentarius Commission recommended acceptance of all types of food irradiated up to 10 kGy for consumption, most governments opted for approval of irradiated food on an item-by-item basis, and occasionally, on specific groups of food, e.g. fruits, vegetables, cereals, roots and tubers, etc. Collectively, 36 countries have approved more than 40 individual irradiated food items for consumption. The types of irradiated fresh fruits which have been approved by national health authorities in different countries are shown in Table 4. Only Israel, United Kingdom, United States of America, and the Union of Soviet Socialist Republic (USSR) have approved all types of irradiated fresh fruits. Eleven other countries have approved individual irradiated fruit items for consumption. The purpose for irradiating these fruits are either for insect disinfestation or shelf-life extension. Most of the approval of irradiated food including fresh fruits for consumption occurred in the 1980s especially after the adoption of the Codex General Standard for Irradiated Food in 1983.

It is significant to note that while the US Food and Drug Administration has approved all types of irradiated fresh fruits for consumption, the USDA-Animal Plant Health Inspection Service (APHIS) has issued a specific regulation on irradiation of Hawaiian papaya in January 1989 (USDA, 1989). This regulation allows the use of irradiation, at a minimum dose of 0.15 kGy, to disinfest papaya from several species of fruit fly endemic in Hawaii in order to satisfy federal quarantine regulation. Later that year, the North American Plant Protection Organization (NAPPO), represented by national plant protection authorities in Canada, Mexico and USA, accepted irradiation as a quarantine treatment of fresh agricultural produce (NAPPO, 1989).

**Irradiation to facilitate international trade in fresh tropical fruits**

Currently, GATT negotiations are in progress in order to harmonize sanitary and phytosanitary measures on as wide a basis as possible, based on international standards, guidelines or recommendations where they exist. Once harmonization of regulations is achieved, i.e. the international standard/recommendations are accepted by governments, trade barriers are expected to be removed leading to facilitation of international trade in agricultural products.

Irradiation has been recommended as a broad spectrum quarantine treatment of fresh fruits and vegetables against insect infestation, by an international group of experts at a meeting held in Washington, D.C., January 1991. The meeting was convened by the International Consultative Group on Food Irradiation (ICGFI) established under the aegis of FAO, IAEA and WHO. The conclusions and recommendations of this meeting will be submitted to the International Plant Protection Convention for consideration as an international harmonized quarantine treatment for fresh fruits and vegetables.

In view of the superiority, effectiveness and versatility of irradiation as a quarantine treatment for fresh fruits and vegetables, some countries like Chile, Mexico and the USA are seriously considering its use to disinfest fruits such as mangoes, papaya, citrus, and grapes against fruit flies and other insects quarantined by state and national authorities. Since most tropical fruits are susceptible to infestation by these insect pests, the role of irradiation will be important and in some cases, unique for treating mangoes against seed and pulp weevils in international trade in these commodities. With the positive consideration of the USDA on the use of irradiation as a quarantine treatment both for domestic and foreign markets, any party interested in using the technology for this purpose on any type of fresh fruits and vegetables could submit an official request to USDA-APHIS to regulate such use. A commercial irradiation facility is under construction in Malburry, Florida, to process various food items including fruits for both domestic and export markets.

**Benefits to Asia and the Pacific**

Countries in Asia and the Pacific produce abundant quantities and varieties of fruits and vegetables which are virtually unknown outside of the region. One reason why these commodities are not well known in Japan Europe and USA is the trade barrier based on strict plant protection and quarantine regulations. Fruits native to the region such as mangoes, litchis, rambutan, longan, mangosteen, pamalo, etc. would be attractive to lucrative markets if quarantine barrier can be overcome. Irradiation offers an excellent opportunity to overcome this barrier in trade in these delicious fruits.

**Further uses of irradiation as a quarantine treatment**

In addition to being an effective and broad spectrum quarantine treatment of fruits against infestation by fruit fly, irradiation has a potential as a quarantine treatment of other food and agricultural commodities such as vegetables, cut-flowers, roots and tubers, logs and timber, wood chips and tree barks, hays, soils for ornamental plants, etc These commodities are important in international trade and, often, are infested by mites, nematodes and insects other than those of *Tephriditae* family For example, a significant amount of wood and wood product exported from Canada and the USA to Europe and Japan is infested by pinewood nematode which is quarantine in the EC and Japan Starting 1 January 1992, the EC requires all imports of US coniferous lumber be kiln-dried to moisture content below 20% The current capacity of kiln in the USA would not be able to satisfy the demand of the volume of exported wood products from the USA to the EC which is over US$ 1 billion/annum. Hundreds of million dollar worth of cut-flowers and foliage from developing countries are infested by mites and thrips which are quarantine in certain ikmporting countries. Irradiation may provide an effective alternative to overcome quarantine barriers in trade in |these agricultural commodities. A new Co-ordinated Research Programme (CRP) on Irradiation as a Quarantine Treatment of Mites, Nematodes and Insects other than Fruit Fly, has just been initiated by the Joint FAO/IAEA Division to this effect This CRP will be operational starting early 1992 for a period of 6 years

Table 1 General comparison of quarantine disinfestation treatments

| Treatment | Cost Competitiveness | Effectiveness of Quarantine Pests | Logistics | Tolerance of Host Commodities | Residues | Remarks |
|---|---|---|---|---|---|---|
| Irradiation | Good | Excellent | Fair | Very good | Nil | Only method available for mango seed weevil |
| Vapour heat | Fair | Mainly fruit flies | Fair | Good | Nil | |
| Hot air | Fair | Mainly fruit flies | Fair | Good | Nil | |
| Hot water | Good | Mainly fruit flies | Good | Good | Nil | |
| Cold air | Poor | Good | Good | Fair | Nil | Not applicable to many fruits |
| Fumigation | Good | Good | Very good | Very good* | Yes | * Depending on fumigant used |

Table 2 Effects of exposure of fruit fly larvae to gamma radiation on prevention of subsequent adult emergence

| Species | Age of larvae (days) | Host | Dose (Gy) for no emergence | Number of insects tested |
|---|---|---|---|---|
| Anastrepha ludens | Mature | Grapefruit | 50 | 82 |
| (Mexican fruit fly) | Third instar | Mangoes | 100 | 101794 |
| A obliqua | Third instar | Mangoes | 100 | 17491 |
| (West Indian fruit fly) | | | | |
| A serpentina | Third instar | Mangoes | 100 | 105252 |
| (Sapodilla fruit fly) | | | | |
| A suspensa | Mixed | Grapefruit | 25 | 1285 |
| (Caribbean fruit fly) | Mixed | Grapefruit | 154 | 9209 |
| | Mixed | Fla. Mango | 17 5 | 8480 |
| | Mixed | Dom Mango | 25 | 4719 |
| | Mixed | Hait Mango | 80 | 2961 |
| | Mixed | Carambola | 50 | 6423 |
| | Mixed | Grapefruit | 40 | 3808 |
| Ceratitis capitata | Mixed | Papaya | 25-75 | 19000 |
| (Mediterranean fruit fly) | Third instar | Mangoes | 150 | 9092 |
| Dacus cucurbitae | 3-4 | Pumpkin | 150 | * |
| (Melon fly) | Mixed | Mixed | 100 | 18000 |
| D dorsalis | Mixed | Avocado | 100 | * |
| (Oriental fruit fly) | Mixed | Mixed | 100 | * |
| | 5 | Mango | 150 | 197041 |
| | 5 6 | Mango | 100 | 100477 |
| | 5 | Mango | 100 | 131148 |
| | 3-4 | Mango | 150 | * |
| D jarvisi | 5 | Mango | 75 101 | 153814 |
| D tryoni | 5 | Mango | 75 101 | 138635 |
| (Queensland fruit fly) | Third instar | Apples | 75 | >128373 |
| | Third instar | Tomatoes | 50 | 2891 |
| | Third instar | Cherries | 75 | 1484 |
| | Third instar | Avocados | 75 | 213638 |
| | 2 7 | Oranges | 75 | 220328 |
| D zonatus | 1-2 | Guavas | 50 | 664 |
| (Peach fruit fly) | 2-4 | | 50 | 968 |
| | ≥ 4 | | 55 | 776 |
| Rhagoletis indifferens | Mixed | Cherries | 97 | 84369 |
| (Western cherry fruit fly) | | | | |

* Number treated not available

Table 3 Effects of exposure of adults and juveniles of insects and allied forms (other than fruit flies) to gamma irradiation for prevention of subsequent adult emergence or reproduction

| Pest species | Stage treated | Host | Effective dose (Gy) |
|---|---|---|---|
| LEPIDOPTERA | | | |
| *Clepsis spectrana* (rose leaf roller) | fifth instar | rose | 200 |
| *Cydia pomonella* (codling moth) | mature larvae | apple, walnuts | 139 177 |
| *Epiphyas postvittana* (light brown apple moth) | fifth instar | apple | 199 |
| COLEOPTERA | | | |
| *Asynonchus cervinus* | mature eggs | citrus | 150 |
| *Sternochaetus mangiferae* (mango and weevil) | larvae, pupae, adult | mango | 300 |
| HEMIPTERA-HOMOPTERA | | | |
| *Brachycorynella asparagi* | adult | asparagus | 100 |
| *Quadraspidiotus perniciosus* (San Jose scale) | adult | apple | 300 |
| DIPTERA | | | |
| *Liriomyza trifolii* (Serpentine leaf miner) | larvae | chrysanthemum tomato | 80 |
| THYSANOPTERA | | | |
| *Frankliniella pallida* | juvenile | flowers | 100 |
| ACARINA | | | |
| *Brevipalpus destructor* | juvenile, adult | grapes | 300 |
| *Tetranychus urticae* | juvenile | fruits, flowers | 300 |

Table 4 Regulatory approval of irradiated fruits for consumption

| Country | Fresh fruits approved for irradiation |
|---|---|
| Bangladesh | mangoes, papaya |
| Belgium | strawberries |
| Brazil | mangoes, papaya, strawberries |
| Chile | mangoes, papaya, dates |
| China | apples |
| France | strawberries |
| Hungary | strawberries, cherries, pears |
| Israel | all types of fruits |
| South Africa | avocadoes, mangoes, papaya, banana, lychees, tomatoes |
| Syria | mangoes, papaya, dates |
| Thailand | mangoes, papaya |
| United Kingdom | all types of fruits |
| United States of America | all types of fruits |
| Union of Soviet Socialist Republics | all types of fruits |
| Taiwan | mangoes, papaya |

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# TRAINING OF PERSONNEL INVOLVED IN REGULATORY CONTROL

P. POTHISIRI
Ministry of Public Health,
Bangkok, Thailand

## Abstract

Food irradiation can offer its full potential benefit only if irradiation facilities and processes are subject to strict control measures. The training of personnel involved in the process and inspection or control of the process and facilities must form an integral part of all food irradiation control procedures. Thus, training courses for irradiator operators, plant managers and supervisors that address proper processing with emphasis on good manufacturing practices (GMPs), dosimetry, record keeping and lot identification should be organized. For food control officials, training in the appropriate inspection procedures required for food irradiation facilities and processes is essential. Last but not least, voluntary compliance is deemed as an ideal but conceivable strategy to sustain and acceptable degree of quality assurance and facilitate effective control and hence should be promoted.

## Roles of personnel involved in regulatory control

The 1988 International Conference on the Acceptance, Control of and Trade in Irradiated Foods resolved that governments which intend adopting the food irradiation process should develop an appropriate regulatory control mechanism.

Major components of the control mechanism include appropriate regulatory requirements and measures, responsible control agency(ies) and the infrastructure for implementation or enforcement.

The availability of qualified personnel is, however, one of the most important factors in the implementation of regulatory control. These persons may have various roles according to the provisions prescribed by law. Some may be involved in the pre-marketing process of licensing or registration of radiation sources and facilities or in the inspection and monitoring of the operations. Some may also help in analysing of food samples collected in order to ensure safety and quality of irradiated foods. The law may also require food irradiation plants to employ full-time qualified personnel with specific training/education.

Inspection of the food irradiation plant often includes monitoring, auditing and supervision. There are also some variations in the degree of inspection i.e. routine, intensive or special mission. Intensive inspection will be conducted from time to time when there is a need for an elaboration on certain matters. It is similar to routine inspection but with greater detailed checking and in-depth investigation. Special inspection is an ad hoc activity, to be carried out in response to complaint or in a special event, mostly concerning compliance problems.

Radiation sources and maintenance would also be inspected by the government authority that looks after the application of nuclear energy.

In most cases, the task of regulatory control of food irradiation will be assigned to the agency responsible for general food control. Food irradiation regulations may be issued under the provisions of general food legislation. Selected food inspectors, therefore, will be given the responsibility of food irradiation plant inspection. These people need to be trained adequately prior to carrying out their assignment.

## Training of plant operators and personnel in food irradiation industries

Plant operators and various personnel involved in food irradiation processing form the most crucial factor in ensuring the final integrity of food products treated by irradiation. Consumer risks, in this case, could only be kept to the minimum if these personnel are competent and responsibly carrying out their assignments according to the relevant codes of good practices in addition to regular inspection by responsible authorities. To attain such an ultimate objective, there are at least several points that the industry should take into consideration regarding the roles and functions of its personnel.

(a) To define clearly the organization (organization chart) and functions of various departments and personnel by adopting the principles and approaches laid down in the internationally agreed Codes of Good Manufacturing Practices (GMP) and Good Irradiation Practices (GIP).

(b) To recruit personnel with proper qualifications and organize a programme to enhance and sustain their relevant competencies.

(c) To establish and employ 'Standard Operation Procedure (SOP)' that prescribes all the detailed instructions and directives for an individual's work to be carried out.

(d) To establish a good documentation system of good record keeping on all required matters such as attachment to safety instructions, dosimetry, handling of incoming and outgoing goods, lot identification, etc. It is recommended that computerization should be employed in order to enhance accountability.

(e) To set up a programme of internal auditing in order to promote and sustain a high degree of voluntary compliance.

Training programmes for plant operators and other personnel involved in food irradiation processing may be divided into pre-service and in-service training. These people should be adequately trained both in theoretical knowledge and practical skills with respect to various aspects of plant operations such as source, operation, dosimetry, handling of products, etc. prior to initiating work in the plant. Emphasis should be given to the principles of quality assurance through the employment of relevant codes of good practices and assessment should be made to assess the understanding of and attachment to such principles.

In order to regularly update the knowledge and skill of plant personnel, particularly in matters concerning the introduction of new or special techniques of irradiation processing, an in-service training programme should be established both in-house and through external organizations/institutions.

Although the above-mentioned training may be included as part of a technology transfer package between respective industries, such a package may not be comprehensive enough and the recipient industry may lack readiness to act on its own. The responsible authorities, therefore, should render technical assistance to such industries, either in isolation or in coordination with relevant international organizations such as FAO and IAEA. A list of some training activities offered by FAO/IAEA in 1992 is in Annex 1 of this paper.

**Requirements of inspectors**

Experienced food inspectors could be trained to become competent food irradiation inspectors but it is not an easy task. There are at least 3 main areas of both theoretical knowledge and practical experience which have to be incorporated in such a training course.

(a) Scientific knowledge concerning nuclear energy, its applications and the irradiation process with an emphasis on food application. Information about radiation sources, installation and maintenance, quality control of irradiation process, particularly dosimetry, are the most important background knowledge for an inspector to have. Periodical updating of this knowledge and information is necessary since the technology is dynamic.

(b) Quality assurance principles and their application in processing of foods by the irradiation process. Although most food inspectors have already learned the principles of quality assurance and the strategy of employing GMP, it is still necessary to review the concept and application of this sensible approach as well as addressing GIP.

(Quality assurance principle requires that quality of a product must be a built-in property - starting from raw materials and passing through various steps in food processing until turning into a finished product).

The food irradiation process is a treatment to preserve food products/food ingredients by way of decontamination or extension of shelf life unlike other preservation techniques such as drying or freezing, yet the same food processor may consider irradiation as an integral part of their overall manufacturing process. However, the food irradiation process may be operated by a plant totally separated from the processor of a food product and operate on the basis of a service contract. Therefore, it is necessary to have separate code of practices for food irradiation. The Codes of GIP which have been developed by the International Consultative Group on Food Irradiation (ICGFI) so far deal with groups of product rather than individual product for the sake of simplicity and practicability. Assurances of safety and quality of food irradiation must rely on the use of both codes, GMP and GIP.

(c) Regulatory compliance: The basic form and content of food legislation varied between countries but must have the common objective that is to safeguard the consumer, promote good nutrition and to facilitate trade. Enforcement of a law is only possible if it has stipulated a power for sanctions by the responsible authority against any non-compliance. As a basis of practical regulatory enforcement, however, such authority may need to elaborate further in order to establish an administrative policy or directive to deal with various situations of non-compliance. Competency in regulatory compliance is considered to be one of the major requirements of personnel involved in the regulatory control of food irradiation.

**Role of national authority**

In most cases, there may be more than one authority which is involved in food irradiation plant control. The health authority may act as a coordinator in bringing all concerned agencies together to formulate policies to deal with food irradiation plant control, beginning with the issuance of appropriate regulatory measures, under the food law, to deal specifically with food irradiation and irradiated food and with a clear-cut division of responsibility in term of pre-marketing and post-marketing control as well as prescribing requirement for a full-time qualified personnel at the food irradiation plant. Licensing and registration of the premises, facilities and radiation sources must also be prescribed unless there is already other law existing which deals specifically with such matters. The duty and authority of inspectors as well as inspection procedures must also be clearly specified. Sanctions of non-compliance cases should also be stipulated. Moreover, it may be desirable to incorporate as part of the legislation, development of human resources for regulatory control of food irradiation. For the Third World countries, however, it may be rather difficult and perhaps unjustifiable on a cost/benefit consideration if they try to initiate this training programme for food irradiation inspectors on their own. Technical and financial assistance from developed countries and relevant international organizations are deemed necessary for developing countries to initiate such an attempt.

**Promotion of voluntary compliance**

While it is necessary to have the ability to implement a good control policy, it is also desirable to promote voluntary compliance. When practised by manufacturers, importers and retailers, voluntary compliance is more effective and productive. Enforcement can, at best, be occasional, whereas voluntary compliance is continuous and permanent, emanating from the operators themselves. To promote and encourage voluntary compliance the responsible authorities should incorporate the concept and approaches into the training curriculum of both regulators and plant personnel. The following are some important strategies:

(a) Counsel the operators on health requirements. The industry should, through meetings, interviews and seminars, be made to understand the responsible authority's concerns and objectives in the area of food control.

(b) Provide technical advice. If the industry has difficulty in compliance because of a lack of knowledge or expertise, the authorities could assist by giving advice. Information booklets and materials to keep the food trade abreast of legislation and hygienic requirements should be freely distributed and explained.

(c) Actively promote quality control or quality assurance programmes. Such programmes serve to inform operators about the quality of their products and enable them to adjust and amend lapses of production, where necessary.

(d) Give recognition or incentives to operators who perform well. Factories and retailers which produce food that complies with the regulatory requirements should be given recognition.

**International cooperation and assistance**

Assistance in training of personnel in the field of food irradiation regulatory control may come in the form of bilateral agreement and often arrive as part of a technology transfer package between two countries (e.g. the Canadian government with selected developing countries). Assistance can also come as multilateral or TCDC agreements but this paper emphasizes the role of certain international organizations which have consistently assisted developing countries in training of personnel.

**ICGFI Network for Training on Food Irradiation (INTFI)**

The Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, has provided training opportunities on food irradiation for scientists/officials from developing countries since its inception in 1964. The training enabled numerous scientists/officers to be exposed to advanced techniques in food irradiation to strengthen their research capability and to ensure effective transfer of the technology to local industry. Since 1979, the International Facility of Food Irradiation Technology (IFFIT) has provided, under an agreement between FAO, IAEA and the Ministry of Agriculture and Fisheries of the Netherlands, such training and assisted the Joint FAO/IAEA Division in the assessment of the feasibility of food irradiation. Approximately 500 scientists/officials from some 60 countries have been trained in this field to date.

Since the establishment of ICGFI under the aegis of FAO, IAEA and WHO in 1984, the following training activities have been carried out by IFFIT on behalf of ICGFI:

(a) ICGFI Workshop on Economic Feasibility of Food Irradiation (1986)

(b) ICGFI Workshop on Use of Irradiation to Ensure Hygiene Quality of Food (1988)

(c) Food Irradiation Process Control School for Food Inspectors/Control Officials (1989)

(d) ICGFI workshop on dosimetry methods for food irradiation (1990)

In addition, ICGFI has examined the desirability of establishing an ICGFI Network for Training on Food Irradiation (INTFI). As a result of an enquiry on this topic, experts or representatives from Argentina, Bangladesh, Brazil, Canada, Chile, France, Germany, India, Italy, Malaysia, Netherlands, Poland, Thailand and Turkey have expressed their support for INTFI.

The Centres listed in Annex 2 are proposed to be included in INTFI. Additional Centres which have informally expressed their interest in becoming part of INTFI are included in Annex 3. In the latter group, large-scale demonstration irradiators are under construction or being planned to be constructed.

ICGFI is requested to endorse the establishment of INTFI as per the list detailed in Annex 2, and to allow the Secretariat to update the list when appropriate. Governments of these Centres will be approached by the Secretariat to contribute in- cash or in-kind towards hosting specific training, as part of their contribution to ICGFI from 1991 onwards. Host governments will also be asked to provide technical and administrative personnel to organize training programmes with the Secretariat.

**FIPCOS Food Irradiation Process Control School**

Under the aegis of ICGFI, a Food Irradiation Process Control School (FIPCOS) was established in 1988 with the following primary objectives:

(a) To train operators of large irradiation facilities used for food processing in the proper control of food irradiation, with special emphasis on GMP, dosimetry technique, record keeping, lot identification, etc.

(b) To train food control officials in the proper inspection procedures required in the case of food irradiation and to control the import and export of irradiated foods.

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ANNEX 1

## TENTATIVE PLANS FOR TRAINING COURSES ON FOOD IRRADIATION

| Year | FAO/IAEA Programme (Duration) | | ICGFI (Duration) | |
|---|---|---|---|---|
| 1991 | (a) | General training course on food irradiation (5 weeks) | (a) | FIPCOS for food inspectors/control officials in Latin America (2 weeks) |
| | | | (b) | Training course on the use of irradiation to enhance hygienic quality of food in Asia (2 weeks) |
| 1992 | (a) | Regional training course on food irradiation for Africa | (a) | FIPCOS for operators/plant managers of irradiation facilities (3 weeks) |
| | (b) | General training course on food irradiation (5 weeks) | (b) | FIPCOS for food inspectors/control officials (2 weeks) |
| | (c) | Training Workshop on Harmonization of Regulations and Acceptance of Irradiated Food (2 weeks) | (c) | FIPCOS for operators/plant mangers of irradiation facilities in Latin America (3 weeks) |
| | (d) | Food irradiation technology (4 weeks) | (d) | Regional training course on the use of irradiation as a quarantine treatment in Latin America. |
| | (e) | Training course on process control of food irradiation for Asia (2 weeks) | | |
| 1993 | (a) | Training course on consumer education and dissemination of information on food irradiation* | (a) | FIPCOS for operators/plant managers of irradiation facilities (3 weeks) |
| | (b) | General training course on food irradiation (5 weeks) | (b) | FIPCOS for food inspectors/control officials (2 weeks) |
| | | | (c) | Regional training course on the use of irradiation to enhance hygienic quality of food in Europe and the Middle East (2 weeks) |

ANNEX 2

## TRAINING CENTRES FOR FOOD IRRADIATION

| Country | Institute | Irradiation facility (Co-60/accelerator) | Food Lab. attached | Lecturer available |
|---|---|---|---|---|
| Argentina | Comision Nacional de Energia Atomica, Buenos Aires | 500 kCi | x | x |
| Canada | Canadian Irradiation Centre, Laval | 400 kCi | x | x |
| | Atomic Energy Canada Limited, Whiteshell, Manitoba | Accelerator | x | x |
| | Food Research Centre Agriculture Canada St Hyacinthe, Quebec | 100 kCi | x | x |
| Chile | Comision Chilena de Energia Atomica, Santiago | 100 kCi | x | x |
| China, P R | Shanghai Irradiation Centre, Shanghai | 177 kCi | x | |
| Egypt | National Centre for Radiation Technology, Atomic Energy Authority, Nasr City | 200 kCi | x | |
| France | Commissariat a l'energie atomique Centre d'Etudes Nucleares de Cadarache, Saint Paul Lez Durance | 50 kCi | x | x |
| Hungary | Agroster Irradiatof Co (in cooperation with Central Food Res. Institute, Isotope Research Institute and Univ of Horticulture, Budapest), Budapest | 200 kCi | x | x |
| India | Bhabha Atomic Research Centre, Trombay, Bombay | 80 kCi | x | x |
| Indonesia | Centre for Application of Isotope and Radiation, Pasar Jumat, Jakarta-Selatan | 137 kCi | x | |
| Italy | Pilot Irradiator Cassacia Research Centre, ENEA | 80 kCi | x | x |
| | Electron Accelerator Frascati Research Centre, ENEA | | | |
| Japan | Takasaki Radiation Chemistry Research Establishment Japan Atomic Energy Research Institute, Takasaki | 100 kCi plus accelerators | x | x |
| Malaysia | Nuclear Energy Unit, Bangi | 450 kCi | x | |
| Thailand | Thai Irradiation Centre, Office of Atomic Energy for Peace, Patum Thani (15 km north of Bangkok) | 450 kCi | x | • |

## ANNEX 3

## CENTRES WHICH EXPRESSED INTEREST IN JOINING INTFI

| | | |
|---|---|---|
| France | Strasbourg Irradiation | R&D Centre for Radiation Processing including Centre, Strasbourg food irradiation planned to be established. |
| Germany | Federal Research Centre for Nutrition, Karlsruhe | A pilot accelerator is under construction. |
| U.S.A. | Florida Agricultural Irradiator, Department of Agriculture and Consumer Affairs, Gainesville, Florida | A demonstration electron accelerator is under construction. |

# STATUS OF REGULATORY CONTROL OF FOOD IRRADIATION IN ASIA AND THE PACIFIC — IDENTIFICATION OF GAPS AND DISCUSSION OF NEED FOR HARMONIZATION

P. POTHISIRI
Ministry of Public Health,
Bangkok, Thailand

## Abstract

Among the countries in the Asia and Pacific Region, the status of regulatory control of food irradiation varies from country to country. Such controls range from being non-existent to the application of the recommended Codex Standard on Irradiated Foods and related code of practice. The details of regulatory control in each of the countries of the region that have established regulations are discussed and gaps in these controls have been identified.

Regulatory control on food irradiation is indispensable for a country in order to safeguard consumers as well as to facilitate trade. Without regulatory control systems, countries may not be in a position to accommodate irradiated foods in their market. Inappropriate regulatory requirements or inefficient enforcement may, in fact, act as an obstable to development in the food irradiation industry and international trade in irradiated foods. Hence, harmonization of regulatory control systems should further enhance the development and acceptance of the food irradiation process and trade.

Strategies for harmonization could be carried out in two steps: Firstly, the countries must try to develop national policy and directives for food irradiation control as part of their universal food control laws/regulations and strictly adhere to the principles and approaches of good irradiation practice. Secondly, effective enforcement of regulatory control which is consistent with international standards must be developed.

**Status of regulatory control**

In Asia and Pacific, some countries are applying irradiation for food safety. More than ten irradiated food items, such as onions, potatoes, chicken, wheat, pulse, garlic, cereals, frozen shrimps, spices and fish, have been approved for human consumption by various countries. Food items including spices, frozen seafood and poultry and mangoes have been approved for microbial decontamination and insect disinfestation by the irradiation process. A number of these approvals were the result of the recommendations of the Codex General Standard for Irradiated Foods. Irradiation facilities available for food preservation in Asia and Pacific are summarized in Table 1.

Some countries, such as Bangladesh and India, although approve irradiation decontamination of specific food items, have not yet carried out commercial scale treatment. Interest in the use of irradiation decontamination of foods is expected to increase considerably in the near future. Among countries in Asia and the Pacific, Thailand, perhaps, is in the most advanced stage of introducing regulations permitting the general use of food irradiation for different purposes.

Comparative review of regulatory control of food irradiation in countries of Asia and the Pacific showed that existing legislation varies from country to country although most countries followed, to some extent, the internationally agreed principles laid down in the Codex General Standards for Irradiated Foods. Based on surveys conducted by the International Consultative Group on Food Irradiation (ICGFI) in 1987 and 1991, the status of regulatory control of food irradiation in twelve countries namely, Australia, Bangladesh, China, India, Indonesia, Japan, New Zealand, Republic of Korea, Pakistan, Philippines, Thailand

and Viet Nam, will be reviewed in this paper.

**Form of legislation**

Countries such as Australia, Bangladesh, China, Indonesia, New Zealand, Thailand and Viet Nam have specifically established national regulations which are mainly under the responsibility of the Ministries of Health (see Table 2).

Formal food irradiation legislation has not yet been established in the Philippines and no information is available for India and Pakistan. However, the absence of such specific recognition should not mean that those countries do not accept food irradiation. Still, national regulations are essential tools for the effective implementation of food irradiation control which is necessary to safeguard consumer and promote food trade.

**Methods of control**

Information on methods of control of food irradiation is included in Table 3, based on information available.

Bangladesh - For all irradiated foods, the relevant trade documents shall give appropriate information to identify the registered facility which has been used for food irradiation, the date of treatment and lot identification.

Control of the process within the facility shall include the keeping of adequate records, including quantitative dosimetry.

Premises and records shall be open to inspection by appropriate authorities.

Control should be carried out in accordance with the Recommended International Code of Practice for the Operation of Radiation Facilities use for the Treatment of Foods (CAC/RCPP 19-1979).

Japan - The Food Sanitation Investigation Council advises the Minister of Health and Welfare on the wholesomeness of irradiated food. Permission for an irradiation establishment is prescribed by the Cabinet Order on Food Sanitation Law of 28 August 1972 as follows:

(a) Establishment of a food irradiation facility should be by permission of the Prefecture Government.

(b) A food irradiation establishment should assign a food sanitation supervisor for controlling the process.

Thailand - Operation of radiation facilities for the treatment of food must be specified in the licensing of a premise. Directions for the operation of a radiation facility for the treatment of foods must follow the Recommended International Code of Practice for the Operation of Radiation Facilities used for the treatment of Foods (CAC/RCP 19-1979, Rev.1). The operator of a radiation facility must perform the preservation of food with adequate doses of radiation to achieve maximal efficiency and comply with the provision in Annex No. 1 attached to Notification of the Ministry of Public Health No. 103 (1986) Re: Prescribing the Operation of Radiation Facilities for the Treatment of Food.

A licensed food irradiator is required to submit the following information in order to obtain permission to irradiate a particular food product:

(a) Information on the isotopes to be used, the dosages to be used, the frequency of dosage, and the purpose for which the radiation is proposed.

(b) Experimental data indicating that the radiation dose proposed accomplishes the intended technical effect and does not exceed the amount reasonably required to accomplish this technical effect.

(c) Information on the nature of the dosimeter, frequency of the dosimetry, and data pertaining to the dosimetry and phantoms used with a view to assuring that the dosimetry readings adequately reflect the dose absorbed by the food during exposure.

(d) Data which would indicate the extent, if any, to which destruction of nutrients occurs in the food under the irradiation conditions proposed.

(e) Data establishing that the irradiated food has not been significantly altered in organoleptic or other physical characteristics to render the material unfit for consumption.

(f) The recommended conditions of storage and/or shipment of the food subjected to the irradiation process when compared with a similar food not irradiated.

(g) Detailed reports of tests made to establish the safety of the food under the conditions of such treatment.

There is no information on methods of controlling food irradiation in Australia, China, India, New Zealand, Republic of Korea and Philippines.

**Clearances**

A complete list of all clearances for food products approved for treatment by irradiation that have been issued in the countries concerned is shown in Table 4.

12, 8, 5, 3, 1, 6, 4, 3, 18 and 3 specific food products are approved for irradiation treatment by Bangladesh, China, India, Indonesia, Japan, Republic of Korea, Pakistan, Philippines, Thailand and Viet Nam respectively. No clearances for irradiation of food products have been identified for Australia and New Zealand. The most common food products permitted for irradiation processing are tuber and root crops, such as potatoes, onions and garlic. Irradiation of chicken, frozen shrimps, rice and spices are also widely approved by many countries. Maximum absorbed doses of irradiation treatment of specific food products for different purposes are also shown in Table 4.

For treatment of commonly distributed food products, such as chicken, papaya, potatoes, onions and spices, most of the maximum doses permitted are consistent and in conformity with the Codex General Standard for Irradiated Foods. The Standard serves as an important basis for an approach to harmonize food irradiation control among countries in Asia and the Pacific. While some countries, such as the Philippines and China, may adapt maximum doses assigned to some of the approved products for a specific reason, this should not be an obstacle to the harmonization of clearance.

**Labelling**

Labelling requirements of various countries are shown in Table 5. A statement indicating that food products are treated by irradiation is required on the packing of irradiated foods by countries such as Bangladesh, Japan and Thailand. In addition, the purpose of the irradiation and the designated irradiation symbol or logo are also required to be on the label of irradiated food in Thailand. There is no information on labelling requirements for irradiated food in China, India, Republic of Korea, Philippines, Australia and New Zealand.

Labelling of irradiated food products is important, since it not only informs consumers that the product has been irradiated, but also indicates the purpose for which treatment was given. However, according to the information obtained from our review, there are still some gaps in labelling requirements among countries in Asia and the Pacific. These differences are barriers to trade and could increase costs if different labels are required for shipment to different countries. Harmonization of labelling standards on an international basis would facilitate the printing of labels for internationally traded goods and decrease the costs of irradiated products. Uniform labelling of irradiated products would assist in educating the consumers and also promote an understanding of the nature of irradiated foods.

Of the countries that especially regulate commercial irradiation processing, only Bangladesh, China, Indonesia, Thailand and Viet Nam have reportedly granted authorization to irradiate specific food commercially. There are three countries, Australia, Malaysia and New Zealand, which have regulated the process but not granted any known authorization for commercial irradiation of any food item. A number of countries, including Japan, the Democratic Republic of Korea, Pakistan and the Philippines, although they have not reported promulgation of a regulation specific to processing of food by irradiation, are known to have issued authorizations to irradiate food commercially. In these cases, it must be assumed that the authorizations to irradiate foods are granted under the general enabling provisions of regulations regarding food processing and sale of food.

**Harmonization of regulatory control of food irradiation**

In the case of countries in which food control infrastructure exists, problems to the development of regulations in harmony with its trading partners may be a result of the following:

- Some countries, which have recognized the benefits of the technology, have already enacted specific regulations which vary in many important principles, particularly regarding the procedure for specific product clearance, labelling requirement and enforcement procedures from those proposed by Codex. This has inhibited clearances, particularly in Japan, where regulations are least similar to international codes.

- Some countries may not yet recognize the benefits of and need for this technology and presently having no specific regulations on food irradiation control. These countries should be urged to follow the recommendations of the 1988 Geneva Conference on Acceptance, Control of and Trade in Irradiated Foods and starts reviewing the feasibility of enacting and enforcing specific regulations on control of irradiated foods. Useful information such as guidelines to develop appropriate regulations, the international recommended standard and associated code of practice, etc. can be made available with the assistance of international organizations, such as FAO, WHO and IAEA.

In the case of countries without food control infrastructure, it must inevitably be more difficult for them to start enacting specific regulations for food irradiation control due to the inadequacies of technical capability and resources. The appropriate approach is, perhaps, to formulate a clear cut government policy or directive which could serve as an essential platform for relevant enforcement procedures to be established without necessitating waiting for the whole food control system to be developed. It is also advisable for the countries to adopt the internationally agreed standards as a means for clearance of imported irradiated foods in order to avoid an impediment to international trade. It is also necessary to have a competent authority, staffed with adequately trained personnel, to be responsible for control implementation.

In summary, harmonization of regulatory control, focusing on adoption of some standards and control procedures, based on internationally agreed principles, is necessary among countries in Asia and the Pacific in order to promote the food irradiation industry as well as to eliminate trade barriers and above all to safeguard public health. However, due to the gaps identified in the current regulatory control of food irradiation in various countries, it makes it difficult for further development of the industry in the region. It is, therefore, necessary to adopt an appropriate strategy by the countries concerned in order to eradicate or lessen such gaps at the regional and also global level. Strategies for harmonization aiming at an elimination of inadequate regulatory control may be carried out in a concerted fashion as follows:

(a) A country must develop national policy and directives to control food irradiation for the benefit of food safety, preservation and export, etc. based on internationally agreed principles.

(b) A country may have to review their existing regulatory control status in contrast to such internationally agreed principles and identify gaps which needed to be eliminated.

(c) Wherever feasible, a specific regulation on food irradiation should be promulgated together with an establishment of an effective enforcement programme.

(d) A country must develop a means for an effective management of regulatory control. Inspection and monitoring activities must always receive high attention rather than just having an idle regulation.

(e) The industries should be assisted to develop readiness in order to ensure that the application of food irradiation technology is and will be done under the acceptable conditions Operation of irradiation process and control procedure must always be consistent with internationally agreed standards.

(f) Special emphasis should be paid to a programme on continuous development of manpowers of both regulators and industry, particularly on the aspects of quality assurance and voluntary compliance.

Harmonization of regulations concerning food irradiation among member countries of the EC is a good example of the benefits achieved by such a process. A proposal for a Council directive for the Approximation of Law on Food Irradiation was prepared for single market to be established in 1992 according to the Single Europe Act. The said proposal accepts irradiation of certain types of food such as strawberries, papaya, mangoes, dried fruits, pulses, dehydrated vegetables, cereals, bulbs and tubers, herbs, spices and vegetable seasoning, shrimps and prawns, poultry, frog legs and gum arabic if such foods are irradiated under specified conditions following GIP.

Harmonization of regulatory control of food irradiation among countries in Asia and the Pacific will be greatly assisted by the efforts of international organizations such as IAEA, FAO and WHO.

Table 1. Countries in Asia and the Pacific with irradiation facilities available for food preservation

| Country | Number | Location | Products |
|---|---|---|---|
| Bangladesh | 1 | Chittagong | Potatoes, onions, dried fish, pulses, frozen seafood, frog legs |
| China | 9 | Chengdu, Shanghai, Zhengzhou, Nanjing, Jinan, Lanzhou, Beijing, Tienjin, Daqing | Potatoes, garlic, apples, spices, onions, chinese sausage, chinese wine |
| India | 2 | Cochin, Nasik | Spices, onions |
| Indonesia | 1 | Pasar Jumat | Spices |
| Japan | 1 | Hokkaido | Potatoes |
| Republic of Korea | 1 | Seoul | Garlic powder |
| Malaysia | 1 | Kuala Lumpur | - |
| Pakistan | 1 | Lahore | - |
| Philippines | 1 | Quezon City | - |
| Thailand | 2 | Bangkok, Patumthani | Onions, fermented pork sausages |
| Viet Nam | 1 | Hanoi | |

Table 2. Form of legislation on food irradiation control

| Country | Form of legislation |
|---|---|
| Bangladesh | Specification for Irradiated Foods (1983) adopted by the Bangladesh Standard Institute |
| China | No information available |
| India | No information available |
| Japan | Food Sanitation Law 1947, amended on 8 August 1972 |
| Republic of Korea | General rule of the FAO/WHO recommendations accepted by Ministry of Health and Social Affairs |
| Philippines | No formal food irradiation legislation as yet Codex Standard is used as a reference for clearance |
| Thailand | Notification of the Ministry of Public Health No. 103 (1986) Re: Prescribing the Operation of Radiation Facilities in the Treatment of Food |
| Australia (New South Wales) | The Food Act of 1984 |
| New Zealand | The Food Regulations 1984 issued pursuant to Section 42 of Food Act 1981 |

Table 3. Methods of control of irradiated food

| Country | Methods of control |
|---|---|
| Bangladesh | Registration of facility/control of the process within the facility |
| China | No information available |
| India | No information available |
| Japan | Permission for an irradiation facility establishment for food treatment |
| Republic of Korea | No information available |
| Philippines | No information available |
| Thailand | (1) Permission for an irradiation facility establishment for food treatment<br>(2) Application for licence/registration of irradiated food process/product |
| Australia (New South Wales) | No information available |
| New Zealand | No information available |

Table 4. List of clearances

| Country | Product | Purpose of irradiation | Type of clearance | Permitted dose (kGy) Min Max |
|---|---|---|---|---|
| Bangladesh | Chicken | Shell life extension/ decontamination | unconditional | 7 |
| | Papaya | Insect disinfestation/ control of ripening | unconditional | 1 |
| | Potatoes | Sprout inhibition | unconditional | 0 15 |
| | Wheat and ground wheat products | Insect disinfestation | unconditional | 1 |
| | Fish | Shelf life extension/ decontamination | unconditional | 2 2 |
| | Onions | Sprout inhibition | unconditional | 0 15 |
| | Rice | Insect disinfestation | unconditional | 1 |
| | Froglegs | Decontamination | provisional | 7 |
| | Shrimps | Shelf life extension/ decontamination | provisional | 5 |
| | Mangoes | Shelf-life extension/insect disinfestation/control ripening | unconditional | 1 |
| | Pulses | Insect disinfestation | unconditional | 1 |
| | Spices | Decontamination/insect disinfestation | unconditional | 10 |
| China | Potatoes | Sprout inhibition | unconditional | 0 20 |
| | Onions | Sprout inhibition | unconditional | 0 15 |
| | Garlic | Sprout inhibition | unconditional | 0 10 |
| | Peanuts | Insect disinfestation | unconditional | 0 40 |
| | Grains | Insect disinfestation | unconditional | 0 45 |
| | Mushrooms | Growth inhibition | unconditional | 1 |
| | Sausage | Decontamination | unconditional | 8 |
| | Apples | Shelf-life extension | unconditional | 0 4 |
| India | Potatoes | Sprout inhibition | unconditional | (av) 0 15 |
| | Onions | Sprout inhibition | unconditional | (av) 0 15 |
| | Spices | Disinfection | for export only | (av) 10 |
| | Frozen shrimps and froglegs | Disinfection | for export only | (av) 10 |
| Indonesia | Dried spices | Decontamination | unconditional | 10 |
| | Tuber and root crops (potatoes shallots, garlic and rhizomes) | Sprout inhibition | unconditional | 0 15 |
| | Cereals | Disinfestation | unconditional | 1 |
| Japan | Potatoes | Sprout inhibition | unconditional | 0 15 |
| Republic of Korea | Potatoes | Sprout inhibition | unconditional | 0 15 |
| | Onions garlic | Sprout inhibition | unconditional | 0 15 |
| | Chestnut | Sprout inhibition | unconditional | 0 25 |
| | Fresh and dried mushrooms | Growth inhibition/insect infestation | unconditional | 1 0 |
| | Dried spices | Decontamination | unconditional | 1 0 |
| Pakistan | Potatoes | Sprout inhibition | unconditional | 0 15 |
| | Onions | Sprout inhibition | unconditional | 0 15 |
| | Garlic | Sprout inhibition | unconditional | 0 15 |
| | Spices | Decontamination/disinfestation | unconditional | 10 |
| Philippines | Potatoes | Sprout inhibition | provisional | 0 15 |
| | Onions | Sprout inhibition | provisional | 0 07 |
| | Garlic | Sprout inhibition | provisional | 0 07 |
| Thailand | Potatoes, onions & garlic | Sprout inhibition | unconditional | 0 15 |
| | Dates | Disinfestation | unconditional | 1 |
| | Mangoes, papayas | Disinfestation and delay of ripening | unconditional | 1 |
| | Wheat, rice pulses | Disinfestation | unconditional | 1 |
| | Cocoa beans | Disinfestation | unconditional | 1 |
| | Fish and fishery products | Disinfestation | unconditional | 1 |
| | Fish and fishery products | Reduce microbial load | unconditional | 2 2 |
| | Strawberries | Shelf-life extension | unconditional | 3 |
| | Nham | Decontamination | unconditional | 4 |
| | Moo Yor | Decontamination | unconditional | 5 |
| | Sausage | Decontamination | unconditional | 5 |
| | Frozen shrimps | Decontamination | unconditional | 5 |
| | Cocoa beans | Reduce microbial load | unconditional | 5 |
| | Chicken | Decontamination and shelf-life extension | unconditional | 7 |
| | Spices and condiments dehydrated | Insect disinfestation | unconditional | 1 |
| | Onion and onion powder | Decontamination | unconditional | 10 |
| Viet Nam | Potatoes | Sprout inhibition | provisional | 0 15 |
| | Onions | Sprout inhibition | provisional | 0 1 |
| | Garlic | Sprout inhibition | provisional | 0 1 |
| | Dry green beans | Insect disinfestation | experimental batch | 1 |
| | Maize | Insect disinfestation | experimental batch | 1 |
| | Paprika powder | Insect disinfestation | experimental batch | 1 |
| | Dried fish | Insect disinfestation | experimental batch | 1 |

Table 5. Labelling requirement on the packing of irradiated foods

| Country | Statement required |
|---|---|
| Bangladesh | ".... (product) treated by irradiation" or<br>" (product) processed by ionizing radiation" or<br>" (product) processed by electron or gamma-radiation" |
| China | No information |
| India | No information |
| Japan | "Foodstuff processed by ionizing radiation" |
| Republic of Korea | No information |
| Philippines | No information |
| Thailand | "Food is irradiated for ..... (purpose of irradiation)" along with an irradiation symbol |
| Australia (New South Wales) | No information |
| New Zealand | No information |

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# DEVELOPMENT OF UNIFORM REGULATIONS, STANDARDS AND CONTROL MEASURES — INTERNATIONAL EFFORTS

(Session VI)

**Chairman**

**P. POTHISIRI**
Thailand

# CONTROL OF GOOD IRRADIATION PRACTICES AND THE ROLE OF THE ICGFI GUIDELINES AND CODES

N. TAPE
Ottawa, Canada

**Abstract**

Considerable guidance is available to managers of an irradiator plant on ways and means to produce safe, wholesome, quality irradiated foods. The foundation for good manufacturing practices (GMPs), which apply to all food processes, is the Codex General Principles of Food Hygiene. These principles provide good common sense procedures in the handling of food for human consumption in order to ensure safe, wholesome quality products. The GMPs cover the growing, harvesting, preparation, processing, packaging, storage, transport, distribution and sale of food. They provide good check lists for safety and quality. More detailed guidelines specifically aimed at food irradiation are found in the Codex Code of Practice for the Operation of Irradiation Facilities and in the Codes of Good Irradiation Practice (GIPs) developed by the International Consultative Group on Food Irradiation. GIPs are available for eight commodity groups. They provide guidance on pre-irradiation handling (including microbiological guidelines), packaging, pre-irradiation storage and transport, irradiation facilities and absorbed doses, post-irradiation storage and handling, final product specifications, labelling, re-irradiation and the quality of irradiated products. In order to apply GIPs effectively, it recommended that the Hazard Analysis Critical Control Point concept (HACCP) be implemented. The HACCP concept emphasizes prevention of, rather than detection of defects. The HACCP concept has been adopted by the Codex Alimentarius Commission and is being applied to Codex Codes of Practice.

As background to Good Irradiation Practices (GIPs), this paper provides an overview of Good Manufacturing Practices (GMPs) for all food and beverage manufacturing. It also briefly outlines the scope and nature of three important documents adopted by the Codex Alimentarius Commission - i.e.

- Codex General Principles of Food Hygiene (1979)
- Codex General Standard on Irradiated Foods (1983)
- Codex Code of Practice for the Operation of Irradiation Facilities Used for the Treatment of Foods (1983)

The Codex documents provide the foundation for the more detailed guidelines found in the codes of Good Irradiation Practice (GIPs) developed by the International Consultative Group on Food Irradiation (ICGFI) and published in 1991.

**Overview of good manufacturing practices**

GMPs describe good common sense procedures in the handling of food for human consumption. Effective application of GMPs ensure safe, sound and wholesome food products. The practices cover the growing, harvesting, preparation, processing, packaging, storage, transport, distribution and sale of food.

Codes of hygienic practice complement food standards by describing <u>how</u> to avoid the contamination or deterioration of agricultural and fisheries produce as it is handled from raw material production to processing to distribution and sale. Application of the codes helps to build quality into the product as it is produced.

Codes of practice are very useful to manufacturers since they provide:

(a) check lists for safety and quality;

(b) guidance in setting up facilities, equipment, methods of control;

(c) guidance on internationally recommended methods;

(d) grounds for supporting recommended practices and rebuttal of criticism or complaints; and

(e) documentation for training courses.

International codes of practice have been elaborated and adopted by the Codex Alimentarius Commission. They include:

- Codex General Principles of Food Hygiene
- Specific Codex Codes of Hygienic Practice for over 35 commodities.

**Codex general standard for irradiated foods**

This standard was adopted by the Codex Alimentarius Commission in 1983. It applies to foods processed by gamma rays from radionuclides, X-rays and accelerated electrons from machine sources. In essence, it approves irradiation processing of foods up to 10 kGy. This standard emphasizes that irradiation is justified only when it fulfills a technical need or where it serves a food hygiene purpose, and should NOT be used as a substitute for Good Manufacturing Practices. This standard also describes appropriate labelling of irradiated foods. The adoption of this standard by Codex made a significant contribution to the commercialization of this useful food conservation technique. Approximately 40 countries now have regulations which permit and control the irradiation of foods.

**Codex code of practice for the operation of irradiation facilities used for the treatment of foods**

This Codex Code provides guidance to the operation of irradiation facilities based on the use of either a radionuclide source (such as Cobalt 60), or X-rays and electrons generated from machine sources. These guidelines apply to continuous or batch type facilities. The code describes the factors which effect the dose absorbed by a product, such as the bulk density of the material to be irradiated, the dwell time or the transportation speed of the product through the irradiation chamber. The need for extensive dosimetry measurements is underlined and accepted methods of measuring the absorbed radiation dose are provided. Although the Code also describes "good radiation processing practices", the text of this section is very general and brief. More detailed guidance is found in the GIPs published in 1991 by ICGFI. The Code also emphasizes the need to separate and identify incoming raw materials and outgoing irradiated products. Records should also be kept which show the nature and kind of product being treated, the nature and extent of treatment received, including dosimetry records. Finally, the Code stresses the need to follow Good Manufacturing Practices, prior to, during and following the irradiation treatment.

**Development and content of good irradiation practices**

Codes of Good Irradiation Practice (GIPs) for eight commodity groups were adopted by ICGFI at its seventh annual meeting in Rome, 1990. The codes were elaborated by ICGFI experts over a three-year period. Government comments on provisional drafts were also received. As mentioned above, the GIPs are complementary to the Codex Standard for Irradiated Foods and the Codex Code of Practice for Irradiation Facilities.

GIPs are available for the following commodities:

(a) insect disinfestation of cereal grains;

(b) prepackaged meat and poultry to control pathogens and/or extend shelf-life;

(c) control of pathogens and other microflora in spices, herbs and other vegetable seasonings;

(d) shelf-life extension of bananas, mango and papayas;

(e) insect disinfestation of fresh

fruits (as a quarantine treatment);

(f) sprout inhibition of bulb and tuber crops;

(g) insect disinfestation of dried fish and salted and dried fish; and

(h) control of microflora in fresh fish and shrimps, and frozen frogs' legs and shrimp.

Each GIP provides the following information:

- foods covered by the code
- purpose of irradiation
- pre-irradiation handling, including microbiological guidelines and GMPs
- packaging
- pre-irradiation storage and transport
- irradiation facilities and absorbed doses
- post-irradiation storage and handling
- final product specifications
- labelling
- re-irradiation
- quality of irradiated products
- references

Another "control" document prepared and adopted by ICGFI in 1990 is the "Guidelines for the Preparation of Regulations for the Control of Food Irradiation Facilities". The document was prepared in response to one of the recommendations made at the International Conference on the Acceptance, Control of and Trade in Irradiated Food, Geneva, 1988. The conference recommended that governments should ensure that regulatory procedures for control purposes are introduced prior to any processing of food by irradiation, or the sale of irradiated food. The ICGFI guidelines describe the registration or licensing of facilities, the regulation and inspection of facilities, documentation and labelling of irradiated food, training of control officials, and employment of good manufacturing practices.

**HACCP**

Let's turn now to how to use GIPs. Traditionally, food quality control has been based on detection of defects in the end product using recognized microbiology, chemical, physical and sensory methods.

In the past decade, a new concept for quality control has been recognized and is being applied throughout the food industry, particularly to food safety issues. It is called the Hazard Analysis Critical Control Point concept (HACCP, pronounced hassip). It is a unique approach to achieving total quality in the food chain.

HACCP was first applied to foods in the 1960s by the Pillsbury Company when it was asked to design and manufacture the first space foods and to provide 100% assurance that food products would not be contaminated with pathogens. They soon found that by using standard methods of quality control (i.e. end product detection tests), there was no way they could be assured that contamination did not exist in the products. They concluded that the only way they could succeed was to have control over the whole process, from raw materials to packaged product.

There are four component steps in establishing a HACCP programme:

(a) assessing the risks and hazards associated with growing, harvesting, processing and manufacturing, distributing, marketing, preparing and using a product;

(b) identifying the critical control points that can regulate the identified hazard;

(c) establishing procedures to monitor the critical control points; and

(d) establishing documentation concerning all procedures and records.

While the application of HACCP appears costly and time consuming, there are many significant advantages, both to industry and regulatory agencies. Some of the advantages of the HACCP approach to ensure food safety are:

(a) HACCP emphasizes prevention of, rather than detection of defects;

(b) It is cost effective because it minimizes the risk of producing defective products that must be scrapped or re-worked;

(c) HACCP is endorsed by regulatory authorities (Codex Alimentarius Commission, Canada, United States of America, etc.);

(d) Management will have greater confidence that defective food is not being marketed;

(e) Food safety verification can be obtained through the recorded information generated by the system;

(f) Inventories are minimized since ingredients from preferred HACCP suppliers need not be held for extensive quality control; and

(g) Greater confidence and justification to sell products at your price.

A good reference on the application of HACCP is the 1991 report of the HACCP Working Group established by the Codex Committee on Food Hygiene. The working group met earlier this year to update the general principles for the application of HACCP to Codex codes of practice.

**Summary comments**

The management team at a food irradiation plant has the following set of resources available to them to help achieve government and consumer acceptance of their products. The quality and safety requirements set forth in national and international standards are achieved through the use of codes of practice and the HACCP system.

(i) International and national standards

National standards are normally in conformance with Codex Standards, such as the Codex General Standard for Irradiated Foods. National legislation and regulations provide the specific detail regarding the approval process and the control requirements, including labelling, for irradiated foods. Codex labelling is described in the Codex General Standard for the Labelling of Prepackaged Foods.

(ii) General codes of practice

Codes of practice provide a check list for management on the operation of a plant and its equipment, raw materials and control methods. The Codex Code of General Principles for Food Hygiene, and the Codex Code of Practice for the Operation of Irradiation Facilities are the relevant general codes.

(iii) Detailed codes of practice

Specific details on the quality and handling of raw materials and processed products from harvest, to storage to market are found in the Codes of Good Irradiation Practice adopted by the International Consultative Group on Food Irradiation.

(iv) Implementation programme

.The stepwise procedure to implement total quality control programme, with built in prevention, rather than on detection, is described in the Hazard Analysis Critical Control Point system.

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# THE ASIAN REGIONAL CO-OPERATIVE PROJECT ON FOOD IRRADIATION WITH EMPHASIS ON PROCESS CONTROL AND ACCEPTANCE: PROGRESS AND ACHIEVEMENTS

P.M. NAIR
Bhabha Atomic Research Centre,
Bombay, India

## Abstract

The above project funded by UNDP has been initiated with objectives to ensure effective transfer of food irradiation technology to local industry in the member countries, to entice private entrepreneurs to venture into this new technology and to convince the consumer and general public about the merits of this technology. In order to achieve these goals, there should be an emphasis on process control based on Codex Standard and the Code of Practice. The national authorities have to shoulder the responsibility to enact proper legislation and also to undertake the training of operators and supervisors for running the facility. The member states should also harmonize the regulations and legislations in the region to encourage trade in irradiated foods.

Many countries in this region have done active research and development work in the past to develop irradiation technology to the present status. Some of the countries in this region like the People's Republic of China, Indonesia, Republic of Korea, Japan and Thailand, have already processed certain food items and ingredients for commercial use. Other countries are in the process of formulation of regulations for trade in irradiated foods. Presently, our task, in this region, is the transfer of technology by developing suitable infrastructure, liaising with food industries in the region, harmonizing regulations and removing disparities for a coordinated effort to popularize the technology. The need of the hour is to have consumer education through dissemination of factual information on the process. Commercial irradiators have recently been completed in the Republic of Korea and Pakistan and they will be initially used for sterilization of medical products and some scale of food processing. India and Indonesia are each planning to have a commercial irradiator in the near future. China has already established an irradiation centre for food items.

Through the support extended by UNDP during the third phase of the Asian Regional Project, it is expected to achieve a collaborative approach of research and development, technology transfer, training of scientists and officials and harmonization of national regulations in the region. These efforts will eventually lead to wide application of this technology for food preservation in the region and help member countries to benefit from increased exports.

The research and development activities undertaken in this project have given fruitful results and helped to boost consumer awareness which will serve as a prelude international trade. The major aspects covered in this project are disinfestation of stored food and tropical fruits, sprouting inhibition of potatoes, onions and garlic, decontamination of meat, fish and fishery products (especially elimination of pathogens) and decontamination of spices. Test marketing and public acceptance programmes conducted for different food items in different countries showed that consumers prefer good and hygienic food whether or not it is irradiation processed. Under this programme, a workshop on public information was held in Bangkok, Thailand from 27 to 31 May 1991, to provide factual information on food irradiation to the members of national press corps and consumer organizations of several countries of the Region. The second Regional Committee Meeting of the Regional Project on Food Irradiation (RPFI) Phase III was held in Jakarta, Indonesia from 15 to 19 July 1991. The major points emerging from this meeting were that better understanding of process control could be achieved through:

(1) Compliance with the Codex General Standard for Irradiated Foods and the Codex recommended international code of practice for the operation of radiation facilities used for treating food.

(2) Inspection, licensing and registration of all irradiation facilities used for treatment of foods.

(3) Adherence to GMP and GIP.

(4) Accurate dosimetry traceable to national or international standards.

(5) Dose mapping for each product type and loading pattern.

(6) Written standard operating procedures specific for each irradiation facility.

(7) Written protocols for each application and food type.

(8) Adequate documentation to follow the treated foods.

(9) Identification of individual consignment and adequate records to enable follow-up of complaints or enquiries.

(10) Quality standard for foods to be irradiated and procedures for inspection and testing upon receipt.

(11) A training programme for operational staff.

(12) A quality assurance system.

These points were considered essential to the harmonization of regulations. Another outcome of this meeting was the collaborative studies that were planned in order to help the countries where there are no facilities for pilot scale irradiation. The programme also provides the opportunity for accepting products from other member countries for studying transport performance, quality evaluation and consumer acceptance.

Spices form an important cash crop of this region. Major countries growing varieties of spices and involved in spice trade are India, China, Malaysia, Indonesia and Sri Lanka. The export trade in irradiated spices is hampered due to non-existence of regulations at a national level and no harmonization of legislation for trade between these and other countries. Presently, clearance and marketing practice varies from country to country making it difficult to evolve a common trade policy. It will be a major achievement for the RPFI Phase III if a common strategy for facilitating trade in irradiated spices is achieved.

**Introduction**

The first phase of the Asia Regional Co-operative Project on Food Irradiation began in 1980 with financial assistance from the Japanese Government. The main objective of the project was to give more emphasis to research and development work, including pilot scale studies on irradiation of selected food items economically important for this region. Subsequently, during the RPFI Phase II period, more importance was given to transfer of the technologies developed to local industry. Currently in RPFI Phase III, more stress is given to process control and it is funded by UNDP. The main objectives of the UNDP supported programme are given below.

**Overall objectives**

- To ensure effective transfer of food irradiation to local industry.

- To develop human resources in this specific field for effective practical application.

**Immediate objectives**

- Process Control: To assist national authorities and the food industry in evolving process control based on Codex General Standards for trade in irradiated foods.

- Training of operators and supervisors for running irradiation facilities. Harmonization of regulations/legislations in the region based on the Codex Standard for Irradiated Foods.

Before reviewing the progress and achievements of the project, it is worthwhile to assess what is the present status of food irradiation in Asia and Pacific region. If one compares the progress of this technology versus its commercial application, one can find that there is still a delay in wider acceptance of this technology for international trade or even for domestic purposes. The cause for this delay is attributed to the absence of proper regulations to govern the food irradiation process. Recognizing this lacuna, many countries are in the process of making proper rules under the existing food laws to control the irradiation process. One of the major concerns of the consumers and the arguments of the consumer organizations opposing food irradiation process is the misuse of this technology to clean up "dirty food" i.e. food that was not manufactured according to Good Manufacturing Practices (GMP).

The FAO/WHO/IAEA/ITC (UNCTAD/GATT) Geneva Conference in 1988 on Acceptance, Control of and Trade in Irradiated Food has considered these matters and recommended that:

(a) Governments should ensure that as a prerequisite to any processing of food by irradiation or sale of irradiated food, regulatory procedures for control are introduced.

Key principles which should be incorporated are registration/ licensing, regulation and inspection of food irradiation facilities, documentation and labelling of irradiated food, training of control officials, and employment of GMP.

(b) Regulatory procedures for the control of food irradiation process should be consistent with internationally agreed principles and embodied in the Codex General Standard for irradiated food and associated code of practice.

(c) Dosimetry traceable to national or international standards should be applied during irradiation process providing means of independent verification.

(d) Governments should ensure that all phases of the planning and operation of food irradiation facilities are subject to a regulatory structure consistent with relevant internationally accepted standards of human health, safety and environment protection.

These guidelines are provided in order to assist identification of key principles for the control of food irradiation facilities and to indicate how these principles should be incorporated into national legislation of a country. Before we go along further, let us examine the purposes of a regulatory control.

(a) To assure that procedure for the irradiation of food are implemented safely and correctly and in accordance with the mandatory provisions embodied in Codex General Standards.

(b) To establish a system of documentation to accompany irradiated foods so that the fact of irradiation can be taken into account during the subsequent handling, storage and use of such foods.

(c) To assist prevention of fraud, such as failure to disclose the fact that irradiation or a false claim, that unirradiated food had been treated.

(d) To facilitate international trade in irradiated foods by establishment and enforcement of uniform and mutually acceptable standards for food irradiation treatment.

It should be borne in mind that the existence of an effective and consistent system of regulatory control both at the national and international level is an important factor in allaying the concern of the consumers over the safety and wholesomeness of irradiated foods. As no sure method exists at present to detect that food has been irradiated and to quantify the applied dose once the treatment is given, effective control of process must be applied. With these views in mind, during the second RCM meeting of RPFI Phase III held in Jakarta, Indonesia from 15 to 19 July 1991, the member countries laid down a redefinition of process control.

Process control was redefined as:

(1) Compliance with Codex General Standard for irradiated foods and the Codex recommended international code of practice for the operation of radiation facilities used for treating food.

(2) Inspection, licensing and registration of all irradiation facilities used for treatment of foods.

(3) Adherence to GMP and GIP.

(4) Accurate dosimetry traceable to national or international standards.

(5) Dose mapping of each product type and loading pattern.

(6) Written standard operating procedure specific for each irradiation facility.

(7) Written protocols for each application and food type.

(8) Adequate documentation to follow the treated foods.

(9) Identification of individual consignments and adequate records to enable follow up of complaints or enquiries.

(10) Quality standard for foods to be irradiated and procedure for inspection and testing upon receipt.

(11) A training programme for operational staff.

(12) A quality assurance system.

It should, therefore, be a mandatory requirement that no irradiation facility is permitted to irradiate food for human consumption unless prior approval to do so has been given by the appropriate national authority. The national authority should be satisfied that the facility complies with all the conditions of safety of workers and environment and also maintenance of good manufacturing and good irradiation practices, control of maximum and minimum doses absorbed should be specified. Of course, this will depend upon the national authority, since the values recommended will depend upon the technological need and this may even vary with single food from one batch to another.

Details of the foodstuff irradiated should be included in the appropriate document for each food irradiation facility and be recorded in the national register. Any specific requirement for a particular food must be recorded. Food intended for irradiation should be of a quality acceptable for good manufacturing practices. Hygienic practices which are needed in GMP for other process are also necessary in irradiation processing. Irradiation should not be used as a substitute for GMP at any stage of production, storage and handling or processing of food. Confidence that irradiation has been properly used is also an important factor in the public acceptability of irradiated foods.

The necessary assurance can only be provided if facilities are operated by adequate numbers of appropriately trained employees under proper supervision by skilled managerial staff. Facilities should also be subjected to regular inspection by inspectors of the national authority controlling food irradiation.

A national register of approved irradiation facilities should be maintained and updated for new information and purposes and should include the following data in respect of each facility:

(a) Details of the national authority granting approval with a reference to the legislation which empowers it to do so.

(b) Details of the national authority responsible for inspecting the facilities to ensure compliance with the condition of approval.

(c) Owner and operator of the facility.

(d) Location and postal address.

(e) Type and strength of the energy of radiation source or sources.

(f) Food or foods which the facility is authorized to irradiate.

(g) Dose limit approved for the process or for individual food items.

(h) Labelling requirement.

(i) Date of approval.

(j) Other relevant data.

The control of the process is also important in ensuring that irradiated food is acceptable for international trade. It is necessary to establish confidence in the irradiation facility in which food has been treated and also in food control authorities of the exporting country, so that importing countries can be satisfied that the process has been applied correctly under GMP and GIP and irradiated food can be accepted for distribution in the importing country.

An international register of licensed food irradiation facilities intended to assist in establishing the confidence and thereby facilitate the movement of irradiated food in international trade. Therefore, it is mandatory that national authorities should also forward the above information to ICGFI Secretariat for incorporation in the national register maintained by ICGFI.

Thus, the key factor in process control can be identified as:

(a) Staffing - adequate numbers, training supervision.

(b) Assessment of initial quality of the food to be treated with rejection of consignments which do not meet the required standards.

(c) Application of the correct radiation dose to achieve the desired technological objective, taking into account the absorbed dose distribution (maximum and minimum dose) within the product.

(d) Use of correct dosimetry techniques (properly caliberated and traceable to national or international standard) both during the establishment of correct radiation dose and during subsequent irradiation treatment of the product.

(e) Physical separation of the incoming unirradiated food from the outgoing irradiated product.

(f) Maintenance of proper conditions for storing and handling the product while in the irradiation plant.

(g) Adequate measures to prevent re-irradiation of any foodstuff except under closely defined and controlled condition.

(h) Maintenance of adequate records concerning the product, the absorbed dose, the dosimetry and caliberation of the dosimetry.

(i) Provision of documentation to accompany treated products.

The developments on food irradiation process in the region are enumerated as given below:

(a) Research and development work on irradiation preservation of foodstuff established radiation technology for number of products.

(b) Some countries in this region are presently processing certain food items or ingredients at commercial scale (People's Republic of China, Indonesia, Republic of Korea, Japan, Thailand).

(c) Most countries are formulating national regulation for trade in irradiated foods.

(d) Commercial irradiators have been completed recently in the Republic of Korea and Pakistan - used for sterilization of medical products and partially for food items. China established irradiation centres for food.

(e) Immediate needs in this region

are:

(i) Technology transfer for developing infrastructure for irradiation;

(ii) Harmonize regulation for removing disparities in trade; and

(iii) Consumer education - dissemination of factual information.

The research and development activities undertaken in this project have given fruitful results and helped to boost consumer awareness which will serve as a prelude to international trade. The major work covered in this project can be elaborated by country wise contribution in different areas.

**Disinfestation of stored food**

Irradiation has shown beneficial effects on the control of insect pests. Efforts are being made to transfer this technology to industry to replace chemical fumigants.

(i) Bangladesh

Semi commercial trials on irradiated pulses and dried fish. Indigenous packaging material to prevent reinfestation was checked. Consumer accepted irradiated products. Intercountry trials on dried fish conducted with Sri Lanka.

(ii) Thailand

Irradiation of rice and mungbean was standardized at commercial scale. Quality evaluation - cooking qualities were tested, found to be acceptable.

(iii) Indonesia

Rice - irradiation did not affect organoleptic and cooking qualities.

(iv) Vietnam

Decontamination of dried fish Herring (28-30% moisture) with 3% salt.

(v) Republic of Korea

Shelf-life extension of boiled-dried anchovies, transportation and quality evaluation studies with India and Indonesia.

**Disinfestation of tropical fruit**

Irradiation has been found to be a viable alternative for ethylene dibromide as a quarantine treatment.

(i) India

Studies on disinfestation of mangoes from seed weevil. Parameters established for control of mango seed weevil by irradiation.

(ii) Philippines

Control of fruit flies in tropical fruits. Intercountry shipments have been planned.

**Sprouting inhibition of potatoes, onions and garlic**

Suitability of irradiation to prevent sprouting losses was established. Technology transfer was initiated in Bangladesh, China and Pakistan.

(i) Bangladesh

Forced ventillation storage of onions. 12 tons onions were stored for five months and sold. Consumers accepted irradiated onions.

(ii) China

Pilot scale irradiation of potato (100 tons) onions (50 tons), garlic (10 tons), apples (30 tons), lychees (800 kg) - stored after irradiation and sold to customers.

(iii) Pakistan

Potatoes (2 tons) stored for six months at 20°C. Onions (2 tons) stored for eight months at (15-30°C). Market trials were carried out. Consumers were happy to buy good quality irradiated foods.

**Decontamination of meat, fish and fishery products**

Complete elimination of pathogens are obtained by irradiation under pre-packed condition in seafoods and meat products.

(i) Pakistan

Decontamination of poultry at 5 kGy plus frozen storage at -20°C - showed substantial reduction in bacterial load.

(ii) Philippines

Extension of shelf-life and improvement of hygienic quality of frozen and chilled prawns. Physico-chemical and organoleptic qualities of irradiated products evaluated.

(iii) Thailand

Improving shelf-life of smoked shrimps - by combination of radiation, packaging and temperature management.

Modified atmosphere - packaging and radiation for extension of cooked shrimps.

Improvement in the quality of fishery products, such as fish burger, by irradiation.

(iv) Japan

Elimination of pathogenic organisms by irradiation in imported frozen shrimps.

**Decontamination of spices and dried vegetables**

Complete decontamination of spices could be achieved by gamma irradiation improving their hygienic quality.

(i) China

Irradiated seasoning (5-8 kGy) reduced microbial load, extended shelf-life. No change in organoleptic properties or nutrient levels, 60 ton of irradiated seasoning were sold to consumers.

(ii) India

Shelf-stability of 10 kGy irradiated spices was examined for one year period. No change in sensory qualities or chemical constituents. Established the suitability of polyethylene, polypropylene and biaxilly orientated polypropylene for packing irradiated spices.

Intercountry transportation and quality evaluation of gamma irradiated and electron beam irradiated spices from Japan were done.

(iii) Malaysia

Evaluated integrity of packaging material, boxes, woven polypropylene material, and Kraft paper for irradiation of black pepper for controlling microbial load. Dosimetry and optimization of package size was done - Packages were suitable for export.

(iv) Sri Lanka

Irradiation decontamination of spices (pepper, cinnamon, nutmeg, cloves and cardamom) after six months storage. A dose of 7.5 kGy was adequate to eliminate bacterial population. Test marketing and consumer acceptance studies are being arranged in cooperation with Government marketing establishments.

Test marketing and public acceptance programmes conducted for different countries showed that consumers prefer good and hygienic food no matter if it is irradiation processed. Apart from giving support for the research activities described above under research contract or agreements, the project also provided assistance to conduct studies on dose mapping in packages containing food products, to Australia, Thailand, and Malaysia. Under this programme, two workshops were also conducted fulfilling objectives of the project. They are:

(1) Techno-economic feasibility of using electron vs isotopic sources held in Takasaki, Japan, 22 October - 2 November 1990. Twelve participants attended this workshop.

(2) A workshop on public information held in Bangkok, Thailand from 27 to 31 May 1991. Fifteen participants from national press corps and consumer organizations from a number of countries attended this workshop and the deliberations will enable them to disseminate accurate information on food irradition to the public.

In this project, collaborative studies were also planned in order to help the countries where there are no facility for pilot scale irradiation. This programme also gives opportunity for accepting product from other member countries for studying transport performance, quality evaluation and consumer acceptance. Such studies planned for this year are given in Table I.

The main crop in this region, which can be treated by gamma irradiation and can enter in international trade is spice. Major countries growing varieties of spices and involved in spice trade are India, China, Malaysia, Indonesia and Sri Lanka. The advantages to start irradiation with spices are:

(1) Being a dry product, packaging, storage and transport are easy to handle.

(2) Since they are used in very limited quantities, it will be advantageous to have a long storage life, if possible, which irradiation can give.

(3) Many countries have cleared irradiation treatment of spices for human consumption.

However, export trade is hampered with the non-existence of regulations at the national level and harmonization of these legislations for trade between these countries and other Western countries. One important fact to consider while according clearances by governments for irradiated foods is to have clearance on a class by class basis rather than on basis of individual food items. Presently, clearance and marketing practices varies from country to country making it difficult to evolve a common trade policy. It will be a major achievement of the RPFI Phase III if we could promulgate a common strategy for facilitating trade in irradiated spices.

Table I Collaborative plans of work among participating countries

| Country of origin | Items | Receiving country | Purpose of transportation |
|---|---|---|---|
| Bangladesh | Onion | India | Quality evaluation |
| | Dried fish | Sri Lanka | Quality evaluation and consumer acceptance |
| China | Dried fish<br>Garlic<br>Spices | Sri Lanka<br>Pakistan<br>Malaysia<br>Sri Lanka | Quality evaluation and consumer acceptance |
| India | Onions | Bangladesh<br>Sri Lanka | Quality evaluation and consumer acceptance |
| | Spices | Japan<br>Sri Lanka<br>Malaysia | Quality evaluation and consumer acceptance |
| Indonesia | Dried anchovies<br>Rice and spices | Korea<br>Japan | Quality evaluation |
| Japan | Electron beam Irradiated spices | India | Quality evaluation |
| Malaysia | Pepper | India | Quality evaluation |
| Pakistan | Onion/Potato | Thailand<br>Sri Lanka | Quality evaluation |
| Viet Nam | Dried fish | Thailand | Quality evaluation |

# A HARMONIZED APPROACH TO REGULATING FOOD IRRADIATION BASED ON GROUPS OF FOODS

R. BRADFORD*, P. LOAHARANU
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture,
International Atomic Energy Agency, Vienna

**Abstract**

Current national approvals to irradiate food are usually specific to a particular food item; even where a whole class of food (e.g. spices) is referred to in approval documentation, clearance is often limited to a specified list of items within that class.

Issue of clearances in this way can lead to undue expenditure of effort on the part of industry and regulatory authorities in submitting and approving repetitive applications to irradiated food items which may be almost identical to others cleared previously.

International trade in irradiated foods may be impeded if the specific food items approved in potential exporting and importing countries do not coincide, despite being closely related.

It is, therefore, proposed that governments should; wherever possible, adopt a policy of issuing clearances for the irradiation of foodstuffs on a class by class basis, rather than on the basis of individual food items. Justifications for such regulatory actions in terms of economics, facilitating trade and harmonization of regulations will be provided.

**Introduction**

It is entirely understandable that early approvals to irradiate food should have been concerned almost exclusively with the wholesomeness testing of single irradiated food items.

Only as the results of extensive wholesomeness testing of a wide range of irradiated foods became available was it possible to demonstrate the similarities between related foodstuffs in their response to irradiation. Some clearances then began to be issued for food classes, such as poultry, fresh fruits, teleost fish and spices; even so, the clearances would often be restricted to a specific list of, for example, spices, and further regulatory action would have been necessary to enlarge the list.

A major milestone was passed in 1980, when a Joint FAO/IAEA/WHO Expert Committee on the Wholesomeness of Irradiated Foods concluded that the irradiation of any food to an overall average dose of 10 kGy causes no toxicological hazard and introduces no special nutritional or microbiological problems.

The effect of this pronouncement on the regulatory control of food irradiation was to transfer the emphasis from the wholesomeness aspects of irradiated foods to control of the irradiation process itself. This change of emphasis was reflected in the Codex General Standard for Irradiated Foods, and the Recommended International Code of Practice for the Operation of Irradiation Facilities used for the Treatment of Food, which were recommended by Codex for adoption by its member states in 1983.

Following these important developments, most countries which allow

* Consultant, Redwing House, Carbinswood Lane, Woolhampton, Reading RG7 5TS, United Kingdom.

food irradiation now require that the process be regulated in accordance with the principles embodied in the Codex Standard, but many still follow a policy of restricting the issue of clearances to specific food items.

This policy causes delays in the extension of commercialization of the process, results in unnecessary costs both to industry and to regulatory authorities, and has a particularly inhibiting effect on the growth of international trade in irradiated foods.

**The advantages of approval on the basis of food classes**

(i) Economic

The procedures for preparing and submitting an application to irradiate food are time consuming and costly, and can represent a significant disincentive to industry if the clearance, when obtained, relates only to a single food item.

Similarly, the examination and processing of applications by national authorities requires the attention and expertise of skilled staff; such authorities have a duty to use their resources to the best advantage, and this is not the case if some submissions relate to foods very similar to those already considered.

Both government and industry, therefore, would benefit economically from a policy of granting clearances wherever possible on a broader basis than that of individual foodstuffs.

(ii) Facilitation of international trade

It is generally regarded as essential that irradiated foods involved or potentially involved in international trade should be subject to approval and regulatory control by the national authorities in both exporting and importing countries; this is also an important prerequisite for consumer acceptability.

Achievement of this objective would be made easier if all countries adopted a policy of approving foods for treatment by irradiation on the basis of food classes rather than on a food by food basis.

The irradiation of tropical and semi-tropical fruits for the purpose of retarding maturation is a particularly good example of a situation that would be made very much simpler by such a policy. At present, each potential use of irradiation for this purpose would be considered, usually by a pair of exporting/importing countries, on the basis of a single type of fruit.

This makes it unnecessarily difficult to extend the use of irradiation for the same purpose to other fruits, both so far as the initial countries are concerned, and for the extension of trade to other importing countries - especially those which may have already approved irradiation to delay maturation, but for different varieties of fruit.

(iii) Harmonization of legislation

It is widely acknowledged that the commercialization and consumer acceptability of food irradiation, as well as international trade in irradiated foods, would be facilitated if all countries were to adopt a consistent set of principles for the regulatory control of the process.

One step in this direction would be a reduction in the current proliferation in the numbers of individual foods permitted to be irradiated in different countries, reflecting the particular needs of the countries at the present time (see Table 1).

Such proliferation generates confusion, not least in the minds of consumers who quite properly question the reasons why a particular item of food should be approved for treatment by irradiation in one country but not in others; the implication being that some countries consider it safe to irradiate a particular foodstuff, while others do not.

A significant reduction in the number of individual clearances issued by each national authority could be achieved if approval were given wherever possible for a food class, rather than for a specific food item. If the same classification system were adopted by all countries, the apparent differences in the range of clearances issued by different countries would be much reduced.

The logical endpoint to the process of grouping foods within classes is, of course, for all countries eventually to give general approval for the irradiation of all foods up to an overall average dose of 10 kGy, in accordance with the conclusions of the 1980 Joint Expert Committee. This would then allow the resources of the regulatory authorities to be wholly devoted towards seeing that the process was being properly applied, irrespective of the food being treated.

However, neither the majority of national authorities nor most consumers representatives are yet ready for this ultimate degree of harmonization, despite the fact that legislation governing the use of other food preservation techniques, where it exists, is almost entirely devoted to control of the processes themselves, and seldom specifies which foods may or may not be subject to preservation by such processes.

**The justification for approval on the basis of food classes**

Two questions, in particular, need to be satisfactorily answered before the principle can be accepted of grouping foods into classes for the purpose of granting clearance to irradiate.

The first is whether the radiation doses given to all the foods within a class are likely to be of the same order of magnitude; the second is whether all the foods within a class respond in the same way when given the same or a similar dose of radiation.

(i) Range of doses within a given food class

The case for grouping foods into classes for clearance would be weakened if different foods within the same class required widely differing doses to achieve the same technological objective.

In fact, major differences in the doses needed to achieve a particular objective do not occur, although in some cases the required doses can differ significantly if two or more technological objectives of irradiation occur within a single class of foodstuffs - for example, to control infestation and to reduce the number of pathogenic organisms.

For this reason, clearance of food classes should be linked with a particular objective of irradiation, and an appropriate maximum absorbed dose prescribed for each objective. This, in fact, was the policy adopted by some of the Joint Expert Committees preceding that which in 1980 recommended a general clearance for all foods up to an overall average dose of 10 kGy.

Further separation of classes or within classes would also be necessary to take account of different physical states of the same foodstuffs, for example, whether produce was fresh or dried (or dehydrated) in the case of fruit and vegetables.

(ii) Response to irradiation within a given food class

Grouping of foodstuffs into classes would also be inappropriate if the foods within a class were to differ widely in their response to irradiation, particularly in respect of toxicological, microbiological or nutritional effects.

However, very extensive testing of irradiated foods has failed to demonstrate such differences, nor indeed would they be expected in view of the chemical similarities which generally exist between foods within a given class.

It was this evidence, in fact, that enabled the members of the 1980 JECFI to recommend a general clearance for all foods, including those which had not been subjected to toxicity testing.

**Arguments against approval on the basis of food classes**

The issue of clearances on the basis of food classes would be seen by some as representing a weakening of the required level of regulatory control of food irradiation in some respects.

(i) The principle of justifiable need

The Codex Standard embodies the principle that the irradiation of food is only justified where it fulfills a technological need or where it serves a food hygiene purpose. Clearly, to approve a whole class of foodstuffs when only a single member of that class actually needs irradiation treatment contravenes, outwardly at least, the principle of justifiable need.

However, this principle can still be applied by imposing a statutory requirement on the irradiation facility to observe Good Manufacturing Practice, including good irradiation processing practice. It follows that it would be an offence for the facility to irradiate food which did not need such treatment.

(ii) Classification of foods

In order to avoid inconsistencies between different countries over the types of food to be included in each class, there would still be a need to specify not only a list of agreed classes of foodstuffs for the purpose of giving approvals for radiation treatment, but also a list of the individual foods recognized as belonging within each class.

(iii) Monitoring of nutritional effect

Some countries, while accepting that the introduction of food irradiation would have no adverse nutritional effect on people consuming a normal balanced diet, nevertheless, wish to monitor the effect on those special groups whose diets may be only marginally adequate, whether for reasons of individual preference or low income.

The ability to control and monitor the introduction of food irradiation in such countries would, at first sight, appear to be diminished if whole classes of foodstuffs, particularly staples, were to be cleared at one time.

In practice, the introduction of clearance on the basis of food classes would not necessarily result in an increase in the amount of irradiated food available to consumers. The application of the process will be determined by demand for this technology by the food industry and the consumers. Assessment of a whole diet for nutritional adequacy is no more difficult or costly if the diet contains several irradiated items or only one; data on which foods have been irradiated, and how much of each, will still be available from records required to be kept by irradiation facilities and importers of irradiated food.

**Conclusions**

It is concluded that the advantages of clearing foods for irradiation on a class-by-class basis, rather than by individual foods, outweigh the disadvantages.

The advantages include a reduction in the cost and time of processing repetitive applications, both for industry and for governments, leading to more rapid commercialization of the process. There would be particular benefits for the development of international trade in irradiated foods. Hence, the following actions are proposed:

(a) Wherever possible, clearance to irradiate food should be given on the basis of complete classes of food, rather than on a food by food basis. Compliance with the Codex Standard in respect of technological requirements (section 4) should be a mandatory condition of such clearances, so that only those foods within a class can be irradiated for which a need has been justified.

(b) In order to facilitate trade, an internationally agreed classification of foodstuffs should be adopted for the purpose of granting irradiation clearances, taking into account the differing objectives or technological needs which can be met by irradiation treatment. The individual foods to be included in each class should also be listed (see Annex I for draft classification).

(iii) There should be an appropriate maximum dose prescribed for each class, and where the objective is the fulfillment of quarantine requirements or the elimination of parasites, a minimum dose should also be specified.

Table 1. Cumulative number of individual national clearances* for various types of food products (involving 34 countries)

| Food products | Up to end 1984 | Up to end 1988 | Increase during 1985-1988** |
|---|---|---|---|
| Vegetables (fresh) | 58 | 100 | 42 |
| Fruits (fresh) | 14 | 32 | 18 |
| Cereals/grains | 9 | 20 | 11 |
| Pulses/seeds | 5 | 16 | 11 |
| Other plant products | 31 | 70 | 39 |
| Meat | 2 | 5 | 3 |
| Poultry | 6 | 12 | 6 |
| Fish, shellfish | 2 | 8 | 6 |
| Other animal products | 4 | 10 | 6 |
| Other food products | 3 | 8 | 5 |
| Total | 134 | 281 | 147 (109%) |

* Total number of clearances, e.g. vegetables up to end 1984 - either one product approved by 58 countries or any other combination of countries and products in between

** Increase in number of new clearances (i.e. not cleared prior to 1985) = 35 (26%)

# DRAFT
# CLASSIFICATION OF FOODSTUFFS FOR THE PURPOSE OF GRANTING CLEARANCES FOR TREATMENT BY IRRADIATION

Class 1 - Bulbs, Roots and Tubers

Purpose of treatment: To inhibit sprouting during storage.
Maximum dose: Up to 0.2 kGy

Class 2 - Fresh Fruit and Vegetables (other than Class 1)

Purposes of treatment: One or more of the following:

(i) To improve keeping quality by delaying ripening.
(ii) To control insect infestation.
(iii) To prolong storage life by partial elimination of spoilage organisms.
(iv) To satisfy quarantine requirements.

Maximum dose: Up to 1 kGy unless otherwise specified

Class 3 - Cereals, Pulses, Dried Vegetables and Dried Fruits

Purpose of treatment: To control insect infestation
Maximum dose: Up to 1 kGy

Class 4 - Fish and Shellfish and their Products, Frozen Frog Legs (Fresh and Frozen)

Purposes of treatment:

(i) Assurance of hygienic quality by reducing the number of pathogenic microorganisms and parasites.
(ii) To prolong shelf-life by partial elimination of spoilage organisms.

Maximum dose: Up to 3 kGy

Class 5 - Poultry and Meat and their Products (Fresh and Frozen)

Purposes of treatment:

(i) Assurance of hygienic quality by reducing the number of pathogenic microorganisms and parasites.
(ii) To prolong shelf-life by partial elimination of spoilage organisms.

Maximum dose: Up to 7 kGy

Class 6 - Dried Herbs, Spices and Condiments

Purpose of treatment: Assurance of hygienic quality by reducing the number of pathogenic microorganisms

Maximum dose: Up to 10 kGy

Class 7 - Dried Food of Animal Origin

Purpose of treatment: To control insect infestation
Maximum dose: Up to 1 kGy

# ACCEPTANCE OF FOOD IRRADIATION TECHNOLOGY — REVIEW OF THE PROBLEM

(Session VII)

**Chairman**

**P. ROBERTS**
New Zealand

# ACCEPTANCE OF FOOD IRRADIATION BY THE CONSUMER — THE VIEWS OF CONSUMERS

J. BEISHON
International Organization of Consumers Union, Netherlands

## Abstract

IOCU is not opposed to the introduction of new technologies. However, we have called for a moratorium on food irradiation until certain outstanding issues have been satisfactorily resolved. Our main concerns are outlined below.

In the past, the public has accepted food technologies about which we had significantly less information than we have about irradiation. But today, consumers generally demand much higher levels of assurance. Too often in recent decades, we have seen new products introduced with claims about great benefits to consumers, only to see them withdrawn or modified substantially as problems become apparent.

There is no doubt that the level of ill-health caused by bacterial contaminants in the food chain is unacceptably high, and WHO has rightly described it as an epidemic. Proponents of irradiation say that irradiating poultry is the best solution to the problem because it will not be possible to establish codes of practice to clean up poultry at source for at least 10 years.

IOCU agrees that irradiation may be the only solution for certain foods where there are no other viable means to prevent contamination, such as for Thai fermented pork Nham sausages. But irradiation cannot be seen as a simple solution for inadequate hygiene. Irradiation is unsuitable for many foods that are known to suffer bacterial contamination, such as whole eggs, meat pate, cheeses and fatty foods.

Furthermore, the resources put into setting up plants to irradiate contaminated food would be better spent implementing good hygienic practices throughout the food chain. Some flocks of chickens are already free from salmonella, and some suppliers have reduced bacteria to low levels by insisting on good agricultural and processing practices.

Promoting irradiation as a solution to poor hygiene fails to focus producers' minds and resources on the grave problem of cleaning up the food chain from its source. If producers act on the philosophy that poor hygiene can be 'put right' by a technical fix at the end of the process, there is every likelihood that standards, in general, will drop; and vulnerable foods that cannot be irradiated may become more contaminated.

Irradiation could undoubtedly help to reduce post-harvest losses by killing pests and inhibiting mould, and proponents often claim that irradiation is needed to increase world food supplies. But resources put into irradiation would be better spent on improved storage facilities to prevent mould growth and infestation, rather than trying to clean food after contamination has occurred. Irradiation does not remove contaminants like mycotoxins, so whether irradiation is applied or not, prevention practices are still needed.

Moreover, the world does not suffer from a food shortage; there is more than enough food produced worldwide to feed the present population. The problems that need to be addressed are poor distribution and economic inequality.

Proponents of irradiation also argue that extending the shelf-life of produce would enable third world countries to increase exports, improving living standards in developing countries and providing consumers in developed countries with a wider range of 'fresh' fruit and vegetables.

But, rather than increasing exports, introducing irradiation may actually damage the image of exports from developing countries. In Europe, the Dutch government has already prohibited irradiation of Dutch-produced fresh fruit and vegetables, to help 'protect' the export market for these products.

Extending the storage life of food can have a marginal value for consumers in keeping food prices down, especially out of season. But experience suggests that the benefits of irradiation will be greatest for the food suppliers, who will have to worry less about getting fresh food into the shops and will be able to store large quantities of foods, releasing them when the market conditions are right.

Consumer resistance to the idea of irradiation is strong, and a number of surveys have shown majorities against the idea. Some of this antagonism is undoubtedly due to misconceptions about the process and unfounded fears associated with radioactivity. But research by Consumers' Association in the United Kingdom found the opposite: in a 1989 survey of 1,918 adults, only 2% described irradiation as making food radioactive. Only 13% said they preferred to buy irradiated food rather than food treated with chemical preservatives.

Consumers have learned to be sceptical about new technologies that are paraded as safe because a number have later been found to bring unanticipated problems. The thalidomide case, for example, has left a strong impression on the public mind.

The effects of irradiation on certain packaging materials, pesticides and other residues have not yet been sufficiently evaluated. There is still controversy about the quality of some of the safety studies cited by reviews that say irradiation is safe. The Australian Government has recently requested a new review of studies on food irradiation, including an assessment of nutritional effects and of the degree to which major studies on irradiation meet contemporary standards for safety tests.

There remain concerns about the control of irradiation plants. While many operators will act responsibly, it will be difficult to control any operator who intends to be unscrupulous. The process needs careful control, for example, to ensure that all foods in a batch receive the correct dose, and that batches do not receive too high a dose on the outside and too low a dose in the centre. Even in plants which have good controls, there can be accidents; at least five irradiation plants have polluted the environment or workers with radioactive materials.

Proponents of irradiation say that if food is labelled, then consumers can choose whether to eat irradiated food or not. IOCU thinks that full labelling is essential to allow consumers to choose. However, it is not possible for consumers to have confidence in labelling until enforcement officers have a reliable and affordable set of detection tests for all the types of foods which are irradiated.

Before a process like irradiation is introduced, there must be seen to be clear advantages for its use, and we must be sure that this technique will not inadvertently create new problems. To date, those advantages have not been demonstrated.

**Introduction**

1. IOCU is opposed to the widespread introduction of food irradiation but it is important to make it clear that IOCU is not simply unthinkingly opposed to the introduction of new technologies. IOCU's responsibilities are to the world's consumers; if a new process can be shown to have substantial benefits for consumers, IOCU would embrace it wholeheartedly provided always that it was also <u>effective and safe</u>.

2. Proponents for the wider use of food irradiation form a powerful pro-irradiation lobby. They have been pressing their case for more than 20 years on a varied range of grounds which are worth listing:

> They talk about world hunger and increasing populations putting even more pressure on the food production system.

> They talk about reducing post-harvest

food losses and produce graphs showing how much more food would be available if this could be achieved.

They talk about the undeniable dramatic rises in foodborne diseases where even WHO are saying that salmonellosis has reached epidemic levels in Europe.

They talk about replacing the dangerous chemical treatment currently used for decontaminating herbs and spices.

They talk about extending shelf-life of perishable foods, for example, papayas and strawberries, to give consumers wider choice.

They talk about the trade advantages to food exporting countries of the slowing of decay and mould growth that irradiation can achieve which it is claimed will open new markets.

Overall, the impression is given that food irradiation will do nothing but good and, somehow, make a major contribution to consumers' well-being, choice and above all safety.

3. Furthermore, the opponents of irradiation are dismissed as either being misguided and emotional consumers who do not understand the technicalities of irradiation or, more sinisterly, as 'professional activists' pursuing some kind of anti-social personal agenda attacking respected companies and institutions for no good reason. Of course, there are some misguided consumers ignorant of all the technicalities of irradiation who equate 'irradiation' with 'radioactive' (although there is evidence that few consumers in the developed world think this). There are also some so-called activistists who have personal objectives and who distort arguments and facts for their own purposes. But this must not be allowed to deflect attention from a rational examination of the claims of the food irradiation lobby.

**IOCU's position and concerns**

4. IOCU has major concerns about almost every aspect of the claims made for irradiation and believes that there are a number of key questions that remain to be answered satisfactorily before the issue of whether irradiation should be used more widely can be properly evaluated.

5. In some ways, the most fundamental question is - who will benefit from the introduction of food irradiation? And this leads to a second question - is there really a need for it, especially on the scale that the proponents are putting forward?

6. Of course, the answer given is - the consumer benefits, and, of course, it is to deal with the problems the irradiation lobby identify. But a closer examination begins to throw some doubt on the validity of these answers.

7. IOCU would like to see some hard evidence on the various claims. For example:

(a) What evidence is there that irradiation would reduce world hunger, in particular, by effectively reducing post-harvest losses?

(b) What evidence is there that irradiation could actually be used to reduce significantly the high levels of *Salmonella*, *Campylobacter* and other foodborne contaminants?

(c) What is the evidence that export trade would be enhanced if irradiation were more widely used?

(d) What is the evidence that consumers want wider choice through the use of irradiation?

8. IOCU is also still concerned about some safety aspects of the process. There are outstanding questions about possible long term effects, for example, that remain to be answered.

**The status of the claims**

9. On the important issue of world hunger, it is hard to find any real evidence that irradiation will do anything to deal with this problem. Sufficient food is produced worldwide to feed the earth's population; the issue is not producing more food, but soling the economic and political problems that prevent food being distributed at affordable prices. This is not to say,

however, that reducing post-harvest losses should not be a high priority but is food irradiation the most cost-effective way of achieving this? There are many simpler, low technology ways of reducing contamination by pests and atmospheric effects. Much contamination by mould and pests is caused simply by poor storage facilities. Leaky roofs and unsecured buildings can be tackled without the use of nuclear technology. Well designed and built warehouses could provide cheaper and appropriate methods of reducing post-harvest losses. Controlled atmosphere storage systems are available. Open air drying can be replaced by hot air systems.

10. Not surprisingly, IAEA is not in the business of promoting these approaches but is FAO investigating them with the same enthusiasm with which it supports irradiation? What are the relative costs of the different methods? What wider implications are there, particularly for developing countries, in spending large amounts of money on nuclear technology which is inherently limited in application compared with broader based general skills? These questions need answering.

11. Contamination from pests and natural decay process have been mentioned in the past paragraph. The same basic argument applies to bacteriological contamination by, for example, *Salmonella* and *Campylobacter*, both of which are on the increase. The overwhelming argument must be - why concentrate on removing contaminants rather than ensuring that they are not there in the first place. It was not that long ago that *Salmonella* was rare in chickens in the shops, now it is reliably estimated that 70% to 80% of chicken is highly contaminated. Dangerous organisms have become endemic in the food chain through the intensification of food production processes and bad hygiene in food manufacturing. Good manufacturing practice has been shown in Sweden and the United Kingdom to be capable of reducing *Salmonella* contamination to acceptable levels. At least one supermarket chain in the United Kingdom claims that it has reduced *Salmonella* levels to below 10% of chickens by insisting its suppliers create and maintain *Salmonella* free flocks.

12. What of the claim that consumers want more choice of 'fresh' foods? Consumers do like choice, but not necessarily at any price. The real test is - do consumers want exotic fruits <u>that have been irradiated</u> to stop them decaying? The evidence is still very strong that consumers do not want irradiated food and the consumer preference studies the irradiation lobby quote do not address this question. There is, of course, a clear benefit to the manufacturing and retailing industries from prolonging shelf-life, a point that irradiation lobby are quick to make when trying to persuade importers and retailers to take irradiated food but noticeably missing from the case put to consumers.

13. Lastly, there is the claim that irradiation will be of benefit to food exporting countries by opening up new markets for them. Again, there is little evidence to support this claim. Countries who are persuaded to go down this route should be made aware that not all countries will permit irradiated food to be sold in their home markets. The EC, one of the world's largest food importing market, has yet to decide on its position and may still come out with a European-wide ban. Even where the markets are open, all irradiated food will have to be clearly and unambiguously labelled, thanks to the Codex Alimentarius labelling requirements.

14. Consumer resistance, whether based on real or imaginary fears, is not likely to disappear for a long time, if ever. Market research evidence suggests that consumers are becoming more and more interested in 'natural' products; the development of the 'organic' food market is evidence of this. The trend is likely to be away from all treated foods and especially those associated with a high technology industry. Even in those countries that allow irradiated foods, the numbers of products are usually strictly limited, monitoring and control regulations are stringent, and very few irradiated products are actually sold. Even some of irradiation's strongest supporters are pessimistic about the future for irradiated foods because they see so many impediments to its wider sale.

**Consumer attitudes**

15. A number of studies are now available on consumer attitudes and some have been dealt with in earlier papers to

this seminar. The evidence is that the majority of consumers are still opposed to irradiated food. What of the studies purporting to show that consumers prefer irradiated foods? When these studies are looked at in detail, it appears that consumers were offered cleaner, fresher looking, more 'perfect' irradiated products which were compared with untreated products with blemishes, sprouts and the like. The consumers' preference is hardly surprising in these cases. But consumers have been offered similarly unblemished fruits produced using pesticides and have increasingly shown that they prefer more 'natural' fresh products. Consumers have, with good reason, become more suspicious of food treatments techniques, especially new ones, as gradually the supposedly once safe pesticides have been outlawed as their long term damaging effects have come to light.

16. Much is also made of taste comparisons with canned foods and foods with other preservatives. Again, it is hardly surprising that consumers might prefer the irradiated product. The proper comparison is to offer consumers a choice between irradiated older food, and the fresh product. We think that the consumer would prefer the fresh product.

17. The irradiation lobby also uses the argument that consumers generally resist the introduction of new technologies and they compare irradiation with the resistance encountered to pasteurization when it was first introduced. This comparison is hardly convincing: the objections to the introduction of new technologies early in this century came from a population that had little experience of science and technology, especially as applied to the food industry. Even in the more developed countries, consumers were not well educated in technology and were used to the provision of fresh foods produced locally. To argue that there are similarities between consumer experience then and now is to ignore the tremendous changes that have occurred in society. And to suggest that pasteurization using heating, a technology that mankind has used for thousands of years, is similar to treatment with ionizing radiation that has been known for less than 100 years is disingenuous.

18 The argument is also used by the irradiation lobby that irradiation has been subjected to more tests and analysis than any other and has been demonstrated to be safe; this misses the point completely. It fails to recognize that consumers expect, and are entitled to have, higher standards of safety now than ever before. If what we now know about the effects of tobacco was known when smoking first became widely used and promoted, does anyone doubt that it would, and should, have been banned? Consumer experience with the whole range of once 'safe' substances from the much quoted thalidomide case to asbestos, rightly means that acceptance standards for new processes and technologies should be greater and more rigorous. Proponents of these new technologies should never forget that it is consumers who in the end pay the price for inadequate testing and evaluation, often with their lives. It ill behooves those who stand to gain from the introduction of irradiation to berate consumer groups whose only remit is to try to protect the consumer.

19. The irradiation lobby seems puzzled that consumers are unwilling to accept the verdicts of scientists, UN agencies and governments. Yet, in a study quoted by Mr Loaharanu in his paper on opinion polls at this seminar, the study in 1987 by Washington State University revealed the rather remarkable finding that only 30% of the group studied "fully trusted FDA's position on food irradiation". It would seem that 70%, therefore, had misgivings about their own food protection agency's judgement. Rightly or wrongly, consumers have surprisingly little faith in scientists, experts or government agencies. We suspect this is because consumers are aware that these people represent a range of interested parties and do not necessarily put the consumers' interests first

**Safety concerns**

20 This is not the place or forum to debate again the various scientific and technical issues that have been raised by IOCU with WHO, FAO and IAEA on the safety of the process. Even though a fairly detailed exchange of documented concerns took place in 1989 and 1990 between WHO and IOCU, we are still very concerned that some of the points raised by IOCU have not been addressed. For example, the early 1980's JECFI report is not fully referenced

and so cannot be checked. Nor is the Karlsruhe data catalogued and available for peer group review as yet. More importantly, many of the studies that the irradiation lobby rely upon for favourable evidence were carried out prior to 1980. There is concern that what today is regarded as good laboratory practice was not followed in many of the studies. The results must, therefore, be suspect. We understand that the Australian Government is sufficiently concerned that they are prepared to make funds available to have the crucial studies reviewed again. This signals a level of concern that cannot be ignored.

21. There are still questions to be answered about the effects of irradiation on pesticide and treatment residues and on packaging materials. The latter are of particular concern as control over the composition and characteristics of many newer packaging plastics is notoriously variable. There are still questions about the effects on certain vitamins and long term effects on nutrition.

22. As important are questions about monitoring and control of the process. Even if the process is adjudged safe when carried out within the limits laid down by WHO, what guarantees do consumers have that accidental or deliberate excesses will be effectively monitored and controlled? The lack of a cheap and reliable detection test is an important issue; consumers are told that the effects of irradiation are so slight that detection is difficult, but it is the <u>hidden</u> effects that may exist that concern consumers. All parties to the debate seem agreed that consumer have the right to choose whether to eat irradiated food or not. How is that right to be protected if there is no detection test so that the standards and inspection bodies can check on consumers' behalf? And if consumers could rely on the honesty of all manufacturers and suppliers, there would have been no need for weights and measures inspectors and the whole range of inspection and protection agencies that governments provide.

**Conclusions**

23. The irradiation lobby starts the debate on irradiation by talking about world hunger and the need for a reduction of post-harvest losses to help feed the world. But the practical selling points turn out to be much more mundane; it seems to come down to giving privileged consumers in the developed world mangoes and papayas that have been picked at a later date and so taste better. Not unreasonably, IOCU is sceptical about the claims that irradiation will solve world food shortages by reducing wastage. Reducing post-harvest losses may have a part to play but so has improving standards of hygiene, preparation and knowledge.

24. The irradiation lobby does not seem to know quite what it is really after; long shelf-life strawberries are not going to solve world hunger and neither is encouraging the transport of exotic foods halfway round the world to promote more consumer 'choice' in the developed countries. The more the case is examined, the more any real benefits seem to be for the producer and retailer, not consumers who demonstrably do not want irradiated food, any more than they want food containing all manner of additives that often serves no useful health purpose.

25. The case for irradiation is mainly being promoted by those with vested interests in the industry and the process. It is IAEA that is leading the campaign for irradiation and since their remit, as defined in Article II of their Statutes, is to:

> "..... seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world ....."

one can hardly blame them for trying to find ways of applying nuclear technology to the food industry.

26. The support given to food irradiation by FAO, the UN agency concerned with food issues, and WHO on the health front, is perhaps more open to question. Understandably, both these agencies face serious and deteriorating world conditions in their areas of responsibility. World hunger seems to rise inexorably despite FAO's efforts and the whole food chain is increasingly contaminated; WHO itself recognizes that foodborne disease is reaching epidemic proportions. There is no doubt that many staff in these agencies genuinely believe

that irradiation will assist in the alleviation, if not a solution, of these problems. But the evidence for this is sadly lacking. This is confirmed, in fact, by Dr Kaferstein of WHO in his paper to this seminar. He says that "..... WHO is not suggesting that these enormous [post-harvest] losses may be prevented by irradiation ....." He goes on to say that WHO wants to give irradiation a chance to see to what extent it can prevent food losses, quite a different matter from saying that it does have a role to play as we are encouraged to believe by the irradiation lobby.

27. The issue of post-harvest losses has already been discussed earlier on this paper and there must be question marks about the role that irradiation can really play here. On contamination, some short term control over salmonella in, for example, chicken might be achieved; but the longer term results are more problematic. The effects of creating a food production system where hygiene becomes of low priority because the industry comes to rely on irradiation to 'clean up' the contamination raise far more serious long term problems.

28. The proponents of irradiation frequently express surprise that consumers take heed of what consumer bodies and IOCU say. The reasons are not so hard to discover: it is because these bodies are among the very few that people have learned to trust. They may not always be right, but people are shrewd enough to see that they have no axe to grind; they are straightforwardly concerned with the consumers' point of view and no one else's. No IOCU organization accepts advertising of any kind or grants from manufacturers or commercial bodies. This means they often have to struggle to find the resources to do their work but this demonstrable independence is their strongest card.

29. In democratic societies, all groups have the right to speak their views and, if necessary, to picket and demonstrate to gain publicity for their cause. It is always surprising to hear the billion dollar food industries and UN agencies complain about the effectiveness of protest groups, however misguided they may be. Industries that can and do spend literally millions of dollars promoting their wares ought to have little to fear from weak, under-funded, consumer groups, but evidently they have. And this is an industry, notorious for its cynicism in misleading consumers, (the 'jumbo' packs that are mostly air, and the specious claims for 'goodness' and 'purity') which then cries 'foul' when consumer groups try to arouse public concern about issues they feel strongly about.

30. IOCU remains opposed to the wider use of irradiation. It has yet to be convinced that all the long term safety concerns have been addressed. It remains to be convinced that irradiation will have the beneficial effects on world food problems that are claimed. It remains sceptical, as do consumers generally, that it is being promoted primarily in their interests rather than in the interests of other parties. It remains concerned about the monitoring, control and prevention of abuse of the process. It is up to those promoting irradiation to satisfy the legitimate and genuine concerns of IOCU and consumers worldwide; it would seem that there is still a long way to go if the proponents are to achieve this.

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# ACCEPTANCE OF FOOD IRRADIATION BY THE CONSUMER — A CRITICAL REVIEW OF TYPICAL MISCONCEPTIONS

N. TAPE
Ottawa, Canada

## Abstract

New technologies are becoming increasingly difficult to introduce. Consumers are concerned about new technologies; they are more aware of mistakes made in introducing them and, therefore, have become apprehensive, particularly regarding food preservation techniques. However, it is enlightening to compare the problems faced today with food irradiation with those experienced several decades ago during the commercialization of pasteurization. Many of the objections to the two preservation processes are identical - e.g. an excuse for the sale of "dirty" food; takes the "life" out of food; diminishes the nutritive value; favours the growth of harmful bacteria; increases food prices. Consumer concerns on food irradiation focus on safety, wholesomeness, cost benefit, information and freedom of choice. In many countries, as well as internationally, consumer organizations are invited to participate in deliberations on food research, food standards and the regulation of new technologies, including food irradiation. Such consultation will be time consuming, but will lead to greater consensus on commercialization of food technologies and the necessary controls. The food irradiation consensus document, elaborated at the 1988 International Conference on "Acceptance, Control Of and Trade In Irradiated Food", describes several actions required to achieve consumer acceptance. Better public information was underlined at the Conference. To date, consumer acceptance, has been based primarily on consumer research polls. However, marketing trials are a better indicator of acceptance since consumers can experience the benefits of irradiation - e.g. better flavour, longer storage. Marketing trials over the past seven or eight years in many countries have demonstrated that consumers, when given a choice, will purchase irradiated foods.

New technologies are becoming increasingly difficult to introduce. Consumers are concerned about new technologies. They are more aware of mistakes made in introducing them and, therefore, have become apprehensive, particularly regarding food preservation techniques.

Recall for a moment the introduction of microwave ovens in the 1960s and 1970s. For several years, many consumers believed that microwave energy leaked from the ovens and that it caused cataracts in eyes or even sterilization of a frequent oven user. Although those hazards exist, the risks became acceptable as manufacturers demonstrated to government regulators and consumers that their ovens were safe to use and that the ovens were very useful appliances in homes and restaurants.

Another example of a technology which was not easily introduced, one which relates more directly to food irradiation, is the pasteurization of wine, beer and milk. Although the process was invented by Louis Pasteur in the mid 1860s, it was not until the late 1930s that objections to pasteurization were overcome in many countries. The review of the early objections to the pasteurization of milk is enlightening, since many of them are identical to those raised today on food irradiation. Some of these objections are listed below:

(a) pasteurization is an excuse for the sale of dirty milk

(b) pasteurization may be used to mask low quality milk

(c) pasteurization promotes carelessness and discourages the efforts to produce clean milk

(d) pasteurization impairs the

flavour of milk

(e) pasteurization diminishes the nutritive value of milk

(f) pasteurization destroys vitamins in milk

(g) pasteurization takes the "life" out of milk

(h) infants do not develop well on pasteurized milk

(i) pasteurization is an artificial expedient; we should not meddle with nature

(j) pasteurization favours the growth of harmful bacteria in milk

(k) pasteurization destroys the healthy lactic acid bacteria in milk and pasteurized milk goes putrid instead of sour

(l) imperfectly pasteurized milk is worse than raw milk

(m) toxins formed by disease bacteria may not be destroyed by pasteurization

(n) dangerous substances might be formed by pasteurization

(o) pasteurization will increase the price of milk

(p) pasteurization legalizes the right to sell stale milk.

Despite the claims that pasteurization was an excuse for the sale of inferior milk, that it would mean the end of clean milk production, and that the nutritional quality would be impaired, pasteurized milk is now common in most countries. In fact, many countries ban the sale of raw milk.

**Consumer attitudes to food irradiation**

Consumer concerns on food irradiation include the issues of safety, wholesomeness, cost/benefit, information and freedom of choice.

Getting the facts to consumers is not easy since in some countries, surveys demonstrate consumer distrust of industry, science and government. Although several United Nations (UN) agencies, many national governments and numerous scientific bodies have endorsed the safety and utility of food irradiation, many consumer organizations actively oppose its use. Consumer uneasiness exists because there is a general awareness of past mistakes where products were declared safe and yet subsequently shown to be potentially hazardous in some manner.

Several myths have arisen about irradiation of food. For example,

- irradiated food is radioactive
- irradiated foods are for museums (i.e. they are dead, not "live")
- irradiation cleans up dirty food
- irradiation promotes the growth of harmful bacteria in food
- the nutritional value of irradiated food is low
- new technology to control pathogens is not required
- irradiation will make food more expensive
- there is no demonstrated need for new technologies, such as irradiation.

Since many of the objections and myths regarding food irradiation are similar to those experienced by "pasteurization", it is likely that the "pasteurization" experience will repeat itself and commercialization of this technology will continue to expand. One of the more difficult hurdles will be to demonstrate to consumers the invisible benefits of the technology - i.e. the same challenge which confronted milk pasteurization 50-60 years ago.

**Who is the consumer?**

There has been a great deal of debate regarding who represents consumers. Are consumer organizations representative of the consumer movement? Do governments represent consumers? These questions were actively debated at the International Conference held in Geneva in December, 1988, on the subject of "Acceptance, Control Of and Trade In Irradiated Food". The conference concluded that "acceptance of irradiated food by the consumer is a vital factor in the successful commercialization of the irradiation process and information dissemination can contribute to this acceptance".

In today's world, it is essential that the consumer movement, even those organizations which may be strongly influenced by activists, must be included in the deliberations leading to use of food irradiation. The International Consultative Group on Food Irradiation (ICGFI) took the initiative to invite the participation of the International Organization of Consumer Unions to attend its annual meetings in an observer capacity. The Codex Alimentarius Commission also welcomes recognized international consumer organizations to attend and participate in Codex meetings. Many national governments have extended the same invitation to consumers to attend "food" meetings on technical issues.

**Acceptance of food irradiation technology**

In 1986, a task force on "Marketing of Food Irradiation", established by the ICGFI, came to the following conclusion regarding the future of food irradiation:

> "The Task Force accepts that the successful introduction of food irradiation worldwide requires a long and sustained effort, with results emerging unevenly according to the regulatory approvals situation in the countries concerned. The problems of convincing the consumer that food irradiation is not only non-toxic, but actively beneficial to decontaminating and preserving food stuffs, are clearly recognized. However, the Task Force is firmly of the belief that a properly programmed effort, flexible enough to adapt to the needs of each country, will ultimately result in the approval, acceptance and utilization of the process."

One should also note the recommendations made by the 57 countries attending the International Conference on Food Irradiation in 1988:

> (a) Governments should ensure that, as a prerequisite to any processing of food by irradiation or sale of irradiated food, regulatory procedures or control are introduced. Key principles which should be incorporated are the registration/ licensing, regulation and inspection of food irradiation facilities, documentation and labelling of irradiated food, training of control officials, and employment of GMPs.
>
> (b) Regulatory procedures for the control of the food irradiation process should be consistent with internationally agreed principles as embodied in the Codex General Standard for Irradiated Foods and its associated code of practice.
>
> (c) Governments should encourage research into methods of detection of irradiated food.
>
> (d) Labelling of irradiated food for international trade should be in line with the provisions adopted by the Codex Alimentarius Commission.
>
> (e) Governments should ensure that all phases of the planning and operation of food irradiation facilities are subject to a regulatory structure consistent with relevant internationally accepted standards for human health, safety and environmental protection.
>
> (f) Governments, especially those that envisage authorization of food irradiation, are encouraged to provide clear and adequate information about food irradiation to the public. The active participation of all interested parties, including consumers, should be encouraged.

As discussed during this seminar, marketing trials are essential in order to show consumers some of the benefits of irradiation. Shelf-life extension can be observed by consumers (e.g. strawberries, potatoes, onions). The better flavour of mangoes and papayas that are picked closer to maturity would also be readily observed by consumers. One of the more important health benefits of irradiation (i.e. the "pasteurization" benefits of irradiation to control pathogens in poultry and meat, seafood and spices) will only be realized when consumer knowledge and concern for food poisoning reaches such a level that they demand government regulatory action.

**Market trials and attitude surveys**

Consumer acceptance has primarily been based on consumer research polls rather than on marketing trials. However, consumer acceptance will not be settled by polls to measure attitudes to irradiation. Consumers are more accustomed to buying and evaluating food itself, not food processing techniques. To this end, market trials provide the strongest data regarding consumer acceptance.

With regard to consumer attitude polls, the major finding on irradiation reveals that the majority of consumers hold no fixed opinion on irradiation, with many consumers not even aware of the technology. When presented with a short statement on the reason for and benefit of irradiation, the polls indicate that a large percentage of consumers would buy an irradiated food rather than an untreated product. Consumer attitude surveys also note significant consumer concern about chemical residues in foods. Therefore, irradiation processing has the opportunity to meet this consumer concern in some applications - e.g. replacement of fumigants. In addition, the longer term outlook for significant markets for irradiated poultry is bright in view of the growing consumer concern regarding contamination of foods by foodborne pathogens such as Salmonella and Listeria.

Market trials of irradiated foods have taken place in many countries - e.g. United States of America, France, Poland, Italy, Israel, Argentina, South Africa, Thailand, Bangladesh, Philippines, and the People's Republic of China. The overall conclusion from these tests is that consumers, when given a choice, will purchase irradiated foods. No market test to date has yielded negative consumer response.

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# ACCEPTANCE OF FOOD IRRADIATION BY THE FOOD INDUSTRY — PROBLEMS AND PROSPECTS

N. TAPE
Ottawa, Canada

## Abstract

Regulatory and safety aspects of the process, equipment, and cost factors, as well as obtaining consumer acceptance are factors which have contributed to the slowness of the commercialization of food irradiation. But there are still other factors equally important in determining the rate of commercialization. They are the pragmatic questions asked by food processors themselves. Will irradiation serve my particular needs? How much will it cost? Is it safe for consumer, customers and employees? What regulations will apply and how much will they cost me? What public relations aspects, including local community attitudes, will I need to address? What will consumers think of my product and how can I find out in advance? What liability issues are involved and are they greater or less than existing ones? Response to these questions will vary considerably. The benefits must be large indeed, if existing capital investment in competitive technology is to be replaced by irradiation. The marketplace does not embrace expensive changes easily or rapidly. Situations in which irradiation may compete are those where there are few established competitive processes, where irradiation provides a unique advantage, where existing processes are inadequate or old, or where a less energy intensive process is required.

# ACCEPTANCE OF FOOD IRRADIATION BY GOVERNMENTS — IDENTIFICATION OF POSSIBLE IMPEDIMENTS TO PROGRESS

P. POTHISIRI
Ministry of Public Health,
Bangkok, Thailand

**Abstract**

Alongside tradiational methods of processing and preserving food, the technology of food irradiation is gaining more and more attention around the world. According to the recent information published by FAO and WHO, 37 countries have cleared irradiated foods and/or irradiated food ingredients for human consumption and international trade in irradiated foods seems to be gaining momentum as food irradiation receives more attention from food industries, particularly in Asia and the Pacific.

In a number of countries in Asia and the Pacific, however, the irradiation process and irradiated foods is still not receiving full government acceptance with some governments establishing a moratorium on the process, some are formulating their position and some have not yet considered the suitability of irradiation technology. The main obstables appear to be associated with consumer uncertainty, the non-existence of/or inadequate regulatory control system, techno-economical bottlenecks and socio-political complications. Each of these major obstacles are addressed in this paper, together with a suggested way forward.

The two key issues are the need to address concerns and correct myths about food irradiation through a comprehensive campaign which includes an extensive education programme for the general public in order to promote consumer acceptance and the need for governments to ensure that adequate regulatory measures on food irradiation control are enacted and effectively enforced.

Food irradiation, as a reliable and efficient preservation process, has attracted increasing attention of governments, industries, consumer groups, the mass media and the public in recent years. According to the recent information published by FAO and WHO, 36 countries have cleared irradiated foods and/or irradiated food ingredients for human consumption. The process is comparable to heating or freezing, in which food products are exposed to a controlled amount of ionizing radiation from an appropriate source to achieve particular objectives, such as sprout inhibition, insect disinfestation, reduction of microbial contamination and extension of shelf-life. The ionizing radiation allowed for these purposes (gamma rays from $^{60}Co$ and $^{137}Cs$ sources, electrons at a maximum energy of 10 MeV and X-rays at a maximum energy of 5 MeV) has too low an energy to induce changes in nuclear structure that would cause any substance to become radioactive. Therefore, after more than four decades of scientific investigation and about two and a half decades of practical experience, one may confidently say that food irradiation is a scientifically and technologically sound process. However, in a number of countries, acceptance of the irradiation process and irradiated foods by governments are still not possible or suffering an indefinite delay mainly due to lacking of a clearcut need for the process/products and consumer concern. The food industries have also been slow in applying food irradiation due to several reasons and one among them is the uncertainty of consumer acceptance of irradiated foods. The successful commercial application of this technology, either at national or international level, thus, requires the involvement of many organizations, both public and private. National authorities must establish appropriate legislation as well as effective implementation schemes in order to ensure the safety and wholesomeness of foods. Provision, by a government, of clear and accurate information about food irradiation to the public is also indispensable. The food industry and the radiation processing industry must recognize the need for standards for radiation treatment of foods. The consumer has the right to make a free and informed choice of a better quality or safer product, national and international organizations must respond to satisfy these needs.

This paper will address a number of issues which may impede the progress in the government acceptance of food irradiation.

**Socio-political complications**

One of the major impediments to government acceptance of food irradiation is consumer concern about the possible drawbacks of food irradiation and the effect of irradiated foods on both human health and the environment. Such doubts have been mistakenly held by some consumers because of publicity over the past four decades about the negative aspects of nuclear energy such as nuclear weapons and nuclear reactor leakage, which overshadow information on the benefits and safety of food irradiation. Inadequate public education plus misinformation on food irradiation by antinuclear activities cause the industry to hesitate in considering the use of this technology.

However, as the 1990s proceed, there appears to be a turning point in the contest over consumer perceptions and political actions. What the 1980s activists, intent upon turning the approvals of and the industrial implementation of food irradiation into a political controversy, did not appreciate at the outset is that they were attacking a process/treatment that is supported by an unmatched accumulation of hard scientific data and information gathered and vigorously evaluated worldwide over decades. The safety/wholesomeness and proven effectiveness of food irradiation have withstood the ultimate test of time, scientific scrutiny and, most recently, the test of industrial application. Also, food irradiation technologies have been well established as environmentally clean, safe and effective in a variety of non-food industrial applications going back many years. For a long range solution, it is of the utmost importance for a government to launch an effective and comprehensive consumer education programme on the safety and benefits of food irradiation/irradiated foods.

**Non-existence of or inadequate regulatory control system**

Since consumer confidence in irradiated food safety and quality could be bolstered by several factors, including effective regulatory control system, regulatory control of the process and irradiated products in food trade by public authorities is essential. Proper controls are particularly relevant to both national and international trade in irradiated food. Control should be exercised at all stages of handling up to the point of sale to consumers.

In principle, regulatory control system comprises at least three main components, i.e. appropriate legislative measures, a responsible competent authority and infrastructure for the implementation of control. Major elements to be included in appropriate legislative measures are the registration/licensing of irradiation process facilities, regulation and inspection of the facilities, documentation and labelling of irradiated food, training of control officials and employment of GMPs. In regard to the second component, the competent authority for assuming responsibility of regulatory control implementation should not be the same agency that is responsible for the promotion of the technology. Consideration should be given to the implementation of regulatory control procedure consistent with internationally agreed principles as embodied in the Codex General Standard for Irradiated Foods and associated Codes of Practices. This approach will avoid the creation of unnecessary obstacles to international trade. As a key to successful implementation of effective regulatory control, it is critical that regulatory personnel should be well and adequately trained on a continuing basis. Moreover, it is also essential for personnel responsible for controlling the plant to have proper training in operation of the facilities, quality assurance principles and procedures as well as in handling of the foods concerned, since self regulation by the industry, based on the principle of GMP, is recognized as a complementary approach for an ultimate assuring of safety and quality of irradiated foods.

**Techno-economical bottlenecks**

There are several techno-economical issues which may impede the progress in the acceptance of food irradiation by governments.

- Lack of need for irradiation: The needs for irradiation have not always been clearly identified because other processing technology is available. However, in Asia and the Pacific region as well as in other tropical and sub-tropical regions, the need to disinfest, to extend shelf-life and to decontaminate various foods by irradiation is probably greater than in the temperate region. For example, quarantine restrictions often prevent certain fresh foods from being exported because of insect problems. Contaminated foods, including those frozen, could also cause illness of the consumers in the importing countries, resulting in severe restriction or ban of further export. The versatility of food irradiation means it is capable of responding to these various needs and should help improve food quality, shelf-life and provide the opportunity to meet quarantine requirements. Moreover, a change in eating habits towards increased consumption of pre-packaged "convenience food" could give rise to an increasing need for application of irradiation in the future to ensure the hygienic quality and prolonged shelf-life of such products.

- Concerns for irradiation interfering with food additives and pesticide residues: Due to extensive uses of pesticides for agricultural production as well as the use of chemical additives in food processing, some industries are uncertain about their interference by food irradiation. According to ICGFI, however, there is no scientific evidence to indicate any health hazard associated with irradiation of food containing pesticide residues and additives. In the United States, the FDA has examined the irradiation of foods containing pesticide residues. It specifically calculated the amount of radiolytic products that would be expected to be formed if foods containing pesticide residues were irradiated at a dose of 1 kGy. If the pesticide residue level in the food is 1 part per million, then total yield of all radiolytic product would be about 0.000033 milligrams per kilogram of food which is virtually nil. Similar kind of studies have also been done in the case of food additives and they found that if 0.01 to 0.01% of additives were used in the food, after irradiation at the maximum dose of 10 kGy, total yields of all radiolytic products will range from 3-30 parts per billion which is extremely low.

- Concerns for large capital investment: By most estimates, to build a commercial irradiator in any part of the world would cost several million dollars - a sizable investment for any food manufacturer or exporter. The economic feasibility may or may not exist if a company does not have a large enough throughput to keep the irradiator busy throughout the year. Conditions, however, probably exist for several companies to pool their resources to build an irradiator.

- Logistics of using an irradiator and need for infrastructure: Food irradiation is economically feasible only when there is a fairly large quantity of produce to be processed. In many developing countries, however, small-scale agricultural production is prevalent. In addition, most of the farms are scattered and inadequate transportation systems cannot bring foodstuffs together rapidly enough to make radiation processing practicable. Also, as there are a variety of foodstuffs that could be irradiated, the development of technology to suit each food would make the average cost per unit too high. With good management and computerization, logistics and scheduling could be optimized and become efficient. A successful implementation of the technology depends also on a proper infrastructure available within a given country. The process has its proper place in those areas where economics have shown a measure of growth and the infrastructure of administration, communication and services are well developed. Effective administration is essential since the process involves high and sustained levels of technology. Constant and substantial supply of raw materials and outlets for the products is required and services such as refrigeration, power and water are of obvious importance.

- Detection of irradiated food: An ability to determine if a food product has been irradiated is a major public concern. It is desirable, therefore, to have available objective test procedures to identify irradiated foods and have a means of measuring the applied dose. At present, however, it can be said that there is no reliable and otherwise satisfactory analytical procedure for the identification of a food as having been irradiated nor is there any means of determining the dose employed. While certain changes in foods resulting from irradiation have been identified, there is no specific change which can serve a regulatory need. A few quantitative identification procedures have been developed. Those include attempts to use chemiheminescence of oxidative products to test for radiation treatment of spices and electron spin resonance technology in dried foods, bones or other hard matrices. Though differences can be found between irradiated and non-irradiated foods, they do not provide a means of analysis that fulfil regulatory objectives. While practical techniques for the detection and determination have not yet been developed, it is desirable to protect consumers by way of labelling control. The competent authority should develop an appropriate control measures to ensure that manufacturers will always comply with such a requirement.

- Nutritional losses: Concern about nutritional losses due to irradiation is often raised by consumer groups as well as relevant public authorities. Nutritional losses due to food irradiation in comparison to any other food process can only be fully evaluated by taking into account the specific applications of irradiation which may be utilized. For example, irradiation of polyunsaturated fatty acids will significantly affect their nutritional value. The significance of these changes will depend on the extent to which dietary sources of polyunsaturated fatty acids are irradiated. This does not present a major risk as major organoleptic changes are noticeable upon irradiation of polyunsaturated fatty acids. Irradiation is not unique in having the capacity to produce nutritional changes in food. Nutrients present in food are also destroyed by other processing methods e.g. sterilization and pasteurization.

- Packaging of irradiated foods: Results of extensive research have shown that almost all commonly used food packaging materials tested are suitable for use at doses up to 10 kGy. Various types of packaging materials have been approved for use when food is irradiated. Their suitability for food intended for irradiation has been studied in Canada, the United Kingdom, the United States, and a few other countries. The USFDA has already approved a number of packaging materials more than 20 years ago. More recently, Canada has approved multilayered polyethylene film as safe for packaging foods which will be irradiated. Sophisticated tests have been used to evaluate the effect of radiation on plastic and other types of packaging materials. Emphases are put on the materials' post irradiation stability, mechanical strength, permeability to water and gases and the extractability of the plastics, additives, and adhesives. Moreover, irradiated materials such as laminated plastic film with aluminium foil are used widely for hermetically sealed products. Other aseptic packaging materials, including dairy product packaging and single-serving containers are also sterilized by irradiation prior to filling and sealing to prevent contamination.

**Conclusion**

Although the safety of irradiated foods has been proven, the opponents of irradiation, in conjunction with wide and unjustified media publicity, have done much to undermine the acceptability of irradiated foods to the consumer. This must be countered by an extensive education programme to lay the foundation for consumer acceptance. The responsibility for education will not only lie with governments but also food industries if they are to succeed at achieving the full potential of the international market. Governments should also ensure that adequate regulatory control mechanisms are in place and that they serve as a facilitator rather than an impediment to trade in irradiated foods. Food industries should be encouraged to examine and define carefully the need for food irradiation and to analyse the economic feasibility of irradiating various foods. One of the possibilities is to increase communication about the technology and benefits among the industry, government and academia.

It must be stressed that commercializing food irradiation has worldwide implications. Economic experts view it as a means of increasing the world food supply. It could also mean expanding exports of many agricultural products of the countries in Asia and the Pacific Region. However, irradiation should not be used unnecessarily to replace other food preservation processes, but only to provide the consumer with a choice e.g. onion with a longer shelf-life, fungicide-free fruit and salmonella-free poultry.

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# CONTRIBUTED PAPERS

# FOOD IRRADIATION IN BANGLADESH

A.S.M. NURUL ISLAM
Bangladesh Standards and Testing Institution,
Dacca, Bangladesh

In Bangladesh, substantial amounts of foodstuff are wasted, due to the absence of an effective preservation method, causing shortages of food every year. Even though conventional methods are used for food preservation, losses remain very high. To avoid this wastage, application of irradiation technology is needed.

The Institute of Food and Radiation Biology of the Bangladesh Atomic Energy Commission (BAEC) are the primary agencies involved in food irradiation research and development in the country. A joint venture company of the BAEC and Bangladesh Export and Import Company (BEXIMCO), known as Gammatech Ltd., is involved in application of irradiation technology.

In December 1983, the Bangladesh Standards and Testing Institution formulated two standards, including one on irradiated foods and a Code of Practice for the operation of radiation facilities for the treatment of foods. These were prepared with the assistance of the Codex Alimentarius Commission. Thirteen different food items have been specified in these standards with dose limits identified. These foods include papaya, potatoes, onions, mangoes, chicken, shrimps, froglegs and fish as well as a few other foods.

A large multipurpose demonstration plant for processing foods is now under construction in the port city, Chittagong, as the joint venture project of the BAEC and BEXIMCO. Construction started in 1990 and was scheduled to be completed in June 1991. However, due to the devastating cyclone and tidal bore on 29 April 1991, the project has not yet been completed.

Regulations on food irradiation are essential for trade of irradiated foods in this region and the international trade of such foods will also facilitate Bangladesh to earn foreign currency.

# APPLICATION OF FOOD IRRADIATION IN CHINA

Jinkang XU
Institute of Food Safety Control and Inspection
Xuegui KAN
Department of Health Inspection and Supervision
Yufang SONG
Ministry of Public Health
Beijing, China

Food irradiation in China has received increased attention in recent years from food scientists, physicists, engineers, government departments, food industry and consumers. Of course, the scientific study of the safety of irradiated foods started more than three decades ago, immediately after the founding of the People's Republic of China in 1949. The subsequent studies can be grouped into three periods of development. In the 1950s and 1960s, a limited number of human and animal experiments were reported, including human feeding trials, involving consumption of irradiated potatoes and rice irradiated at levels of 0.1 kGy and 0.3 kGy respectively. No significant differences were found between experimental and control groups. In the second period of development (the 1970s), a nationwide programme of animal toxicity tests for irradiated foods was carried out under the auspices of the State Committee of Science and Technology. Chronic toxicity tests, multi-generation reproduction tests, teratogenicity and mutagenicity tests were performed on mice, rats and dogs. Foods included in such studies were rice, potatoes and Chinese sausage. No ill effects were associated with the irradiation of these foods. The third period of development has been underway since the 1980s. In this period, the studies have been carried out under the joint organization of the State Committee of Science and Technology and the Ministry of Public Health. In this period, an Expert Group for Evaluation of the Safety of Irradiated Foods was established by the Ministry of Public Health. The Group reviewed and re-evaluated the data from domestic sources, foreign governments and international organizations and drew the following conclusions:

(1) Irradiation was an effective preservation procedure.

(2) There was a lack of human experiments in the 50 years prior to the review.

(3) The main barrier to the expansion of food irradiation was the fear of risks associated with nuclear energy.

Subsequently, a joint State Committee of Science and Technology and Ministry of Public Health meeting was convened in 1982 to discuss promotion of food irradiation as a food processing technology in China. The two major conclusions of this meeting were as follows:

(1) The worldwide data highlighted that foods which had absorbed given levels of ionizing radiation were safe for human consumption. However, there was a need to carry out human feeding trials to provide direct evidence of safety. Such trials were considered the most likely method of dispelling public concerns regarding the technology. It was also concluded that both short-term and long-term trials were required.

(2) Irradiated foods should be controlled by strict standards of hygiene.

Hence, the period 1980-1985 saw a number of chemical and bacteriological examinations of irradiated foods conducted, eight human feeding trials and hygienic standards for many irradiated foods established. Feeding trials examined the effects of feeding a total of 439 people for 7-15 weeks on a diet of irradiated foods including rice, potatoes, mushrooms, peanuts and Chinese sausages. Unlike an Indian report which concluded that irradiated wheat induced polyploidy increase in malnourished children, the Chinese studies showed no significant effect from consuming irradiated food and, in particular, no polyploidy of peripheral lymphocytes was detected.

Hygiene studies, involving many institutions of food safety control and inspection, medical colleges and other organizations were also carried out and, as a consequence, hygiene standards for irradiated rice, potatoes, onions, garlic, peanuts, mushrooms, Chinese sausages and apples were promulgated by the Ministry of Public Health.

From 1986 to the present day, there has been an expansion of the foods for which hygiene standards have been investigated, including standards for fried chicken (as an example of cooked meat products), tomatoes (as an example of fresh vegetables susceptible to deterioration), lychees (as an example of fresh high grade fruit), pollens, nuts, preserved fruit and liquor produced from sweet potatoes.

In studies of the irradiated liquor, 2, 3-butylene glycol was detected and determined to be a radiolytic product. The amount of this compound related directly to the absorbed radiation dose. Hence, this compound may prove useful as a method of determining if such products have been preserved by irradiation.

Studies have also examined the effectiveness of irradiation in controlling select pathogens. Irradiation of pork meat with 0.3 - 1.0 kGy proved effective in the destruction of *Trichinella* while the irradiation of braised chicken delayed the formation of toxin by select strains of *Clostridium botulinum*.

Currently, irradiated apples, tomatoes, onion, garlic, oranges and Chinese sausages are being marketed with some success as consumers, in China, appear willing to purchase such irradiated foods. However, as consumer acceptance of such foods is at an early stage, China originally required relatively strict toxicological tests. If the dose to be used was less than 1 kGy and the food had not been irradiated in China previously, acute animal toxicity and mutagenicity tests had to be performed and at doses from 1 kGy to 10 kGy, additional 90-day animal feeding trials had to be completed. More recently, experts have proposed that at doses less than 1 kGy, no toxicological tests should be performed; while from 1-5 kGy, acute animal toxicity and Ames tests should be completed; and from 5-10 kGy, acute animal toxicity tests, 3 mutagenicity tests, 90-day animal feeding trials and teratogenicity tests should be conducted where necessary. Before using doses greater than 10 kGy, the Expert Group for the Evaluation of the Safety of Irradiated Foods must consider the treatment and a submission must be forwarded to the Ministry of Public Health for reviewing and approval.

As a consequence of all these studies, China has determined that:

(1) Irradiation is a good, effective and reliable method of processing foods for China.

(2) There is a need to dispel public misgivings through education via a range of approaches and channels.

(3) There is a need to assess the economic benefit of the process and to develop extensive commercialization of the process.

(4) The irradiation process and facility should be strictly regulated.

(5) There is a need to strengthen the national study programme on specific radiolytic products.

(6) Human feeding trials employing a larger population for a longer period are necessary and important in achieving consumer confidence in the safety of irradiated food.

In conclusion, the People's Republic of China views irradiation technology as an important means of food processing and preservation which is worthy of further development. It is expected that ongoing research and education programmes will ensure that consumers come to accept this technology as they have other food preservation procedures. It is the responsibility of government to develop food irradiation by paying attention to and promoting cooperation amongst researchers, government, industry and consumers.

# STATUS REPORT ON REGULATIONS FOR PROCESS CONTROL AND TRADE IN IRRADIATED FOOD AND RESEARCH IN INDIA

P.M. NAIR
Bhabha Atomic Research Centre,
Bombay, India

Currently, our research and development efforts are diverted towards standardization of detection methods to identify irradiated products. It is a herculian task to develop suitable methods to distinguish irradiated from a non-irradiated food, especially being a cold process. This brings about only very minor changes in the food composition. However, in proper regulatory control and for allaying the concern of the general public, suitable methods, applicable for individual commodities, have to be developed for identification of irradiated food entering the commercial channel.

We have standardized a rapid microbiological method for distinguishing irradiated fish or meat from non-irradiated ones based on the observation that there was a drastic reduction in the spoilage potential measured as Total Volatile Acid and Total Volatile Basic Nitrogen by inoculation of spoilage bacteria to the homogenate. Similarly, our studies on the spices show that spices, other than curry powder, do not exhibit thermoluminescence in the absence of salt. The property of the common salt to give characteristic thermoluminescence glow was adapted as a test to identify irradiated spices. Sale could be included in the spice package meant for irradiation in a satchet. Thermoluminescence glow of the salt is stable and can be detected even after two years of storage.

The apex body, contributed by the National Government of India, namely, the National Monitoring Agency (NMA) to oversee all aspects related to implementation of food irradiation programme has formulated rules promulgated under the Atomic Energy Act, 1962, to control food irradiation. These rules were approved by the government and it is published in the Indian Gazette, 2 March 1991 issue. NMA has also recommended irradiation of spices, onions and potatoes for domestic consumption. However, it made it clear that clearance could be statutorily effective only when provision for labelling and licensing are laid down under the Prevention of Food Adulteration Rules (1955). After this, test marketing and consumer trials on irradiated food items will be allowed in India.

The Government is also keen to demonstrate the efficacy of the technology to farmers, traders and food industrialists. For this purpose, two irradiation facilities are being planned. Of these, the fabrication of a mobile irradiation facility is nearing completion at Bhahba Atomic Research Centre. In the near future, this facility will be taken out to the locations where onions are harvested and stored for irradiation. Another irradiation facility for spices will be located at Cochin, which is a major spice exporting centre. With these developments, India is venturing into commercialization of irradiated foods.

## FOOD IRRADIATION IN MALAYSIA — CURRENT STATUS OF APPLICATION AND REGULATORY CONTROL

Anuar bin ARIFFIN
Ministry of Health,
Kuala Lumpur, Malaysia

As in most countries of the world, foodborne diseases are still a major problem faced by Malaysia. With a population of 18 million and a relatively low infant mortality of 14.2 (1989), Malaysia still faces a constant threat of foodborne illness from cholera, dysenteries, typhoid, salmonellosis and various other forms of food poisoning. The endemic situation occasionally superimposed by sudden outbreaks is controlled with ongoing surveillance and prompt investigations and remedial actions taken. Though proper handling techniques are very important, food contamination resulting in foodborne illness can be overcome and controlled by various food processing methods which are proven to be effective and safe.

The application of irradiation as an alternative method for the preservation of food is slowly gaining interest in Malaysia. Currently, there are two (2) gamma sources available at the Nuclear Energy Unit, namely a gamma cell with initial activity of 10 kCi, commissioned in 1985 and a multipurpose $^{60}Co$ facility with current activity of 1.5 MCi, commissioned in February 1989. An Electron Beam Machine with an energy of 3 MeV was recently set up at the Unit.

In Malaysia, research on food irradiation started in the 1980s. The primary objectives are to conduct basic research, intensify semi-pilot and pilot scale studies on the use of irradiation for treatment of foods and agricultural commodities with the aim of transferring the technology to food industries. The research projects undertaken include irradiation of such products as milled rice, pepper, cocoa beans, frozen poultry and fruits for disinfection and disinfestation.

Poor public acceptance is an important factor resulting in the slowing of commercialization of food irradiation in Malaysia. The trends of consumerism, in considering the application of food irradiation and irradiated foods are gaining momentum in Asia and other regions. In Malaysia, food processors, scientists, legislators, etc. recognize the fact that consumer acceptance plays a very important role in determining the success of food irradiation. Malaysia, through the Nuclear Energy Unit, has started a public acceptance programme on food irradiation. A survey of 1,000 persons in the Klang Valley carried out in 1990, revealed that 63% of respondents were unaware of, or had not heard of food irradiation and only 2% of the 37% respondents who were aware, had a good knowledge of the technique. Consumers' opinions of the technique indicate that 51% of the respondents considered it to be somewhat dangerous while 39% formed no opinion or undecided and only 10% were convinced it was safe. The survey also indicated that safety assurance has strong positive influence in determining the willingness to consume irradiated food. This is reflected by the increased willingness of respondents to consume irradiated food from 15% to 54% before and after assurance respectively. Based on this important factor, Malaysia has embarked on active dissemination of information on food irradiation through the mass media and will continue to strengthen this activity.

It is observed that the food industry in Malaysia is gradually showing an interest on the technology but is probably hindered by uncertainties in such areas as consumer acceptance, profitability, availability of raw materials, technical support services and regulatory control. A study in 1985 indicated that an irradiation facility for food requires a minimum of 10 000 MT throughput per year to breakeven. Doubts still exist among entrepreneurs regarding the economics of running such a plant for food irradiation, especially with the present system of marketing agricultural products. Therefore, a comprehensive feasibility socio-economy and infrastructure is to be carried out to clarify such doubts.

Irradiation facilities in Malaysia are controlled by the Atomic Energy Licensing Board empowered under the Atomic Energy Act, 1984. The Board is responsible for the control of the safety of the plant, environment and the workers in irradiation facilities in Malaysia. In addition, the control on the application of ionizing radiation on food and sale of irradiated food in Malaysia is controlled by the Director General of Health empowered under the Food Regulations, 1985, of the Food Act, 1983. An interagency Advisory Committee on Food Irradiation advises the Director General of Health on the above matters.

Malaysia is actively involved in the international development of food standards and guidelines such as those of the Codex Alimentarius Commission. General Guidelines for the Irradiation of Foods based on the Codex Alimentarius Commission and the International Consultative Group on Food Irradiation have been circulated for public comments. In the meantime, efforts are being geared towards approving the irradiation of specific food commodities to be incorporated into the existing regulation. One of the most important aspects that will be considered is the manner and forms of labelling that would be made compulsory in order to assist the consumers to make an informed choice. This move would assist the development of the food industry in complying with specific regulatory requirements while protecting the interest of the consumer.

Realising the lack of appropriate technology for the detection of irradiated food, it is felt that an international mechanism for the control of food irradiation and irradiated food be rapidly established in order to safeguard consumer interest and facilitate international trade in food.

# CURRENT SITUATION OF FOOD IRRADIATION IN THE PHILIPPINES

E.F. ALABASTRO
Department of Science and Technology, Metro Manila
O.R. ANGELES
Bureau of Plant Industry, Manila
C.J. PARCE
Department of Health, Metro Manila

Philippines

There is no doubt that food irradiation is an effective means to reduce post-harvest losses through elimination of insect pests and pathogens, control of ripening and senescence and extension of shelf-life as these are well documented in many countries.

In the Philippines, the successful application of food irradiation for sprout inhibition in tubers (onions, garlic, ginger), disinfestation of agricultural produce (rice, corn, mungbeans, coffee beans, copra, mangoes), and microbial control in certain foods (dried fish, prawns, dessicated coconut) showed the potential of irradiation as an alternative to traditional methods of preservation.

Recognizing the worldwide interest in food irradiation, the Department of Science and Technology (DOST) created an Ad Hoc Committee on Food Irradiation whose main task was to review the status of food irradiation in the Philippines as well as developments in other countries, with the view of preparing policy recommendations. The Committee, which is composed of representatives from different government agencies, consumer groups and food industry associations, held consultative meetings and discussed important issues relative to safety of irradiated food, technological benefits of food irradiation, legislation, and consumer acceptance.

Among the recommendations cited in the Committee's report are the following:

1. Food irradiation should be treated as a "process" and not as an "additive". The Bureau of Food and Drugs (BFAD) is requested to prepare the rules and regulations, and an amendment to the Food, Drugs and Cosmetic Act, to effect this change.

2. There should be legislation on the following:

(a) Licensing and control of irradiation process

(b) Prescribed dose limits of irradiated food commodities

(c) Mandatory labelling of irradiated food

3. BFAD should have the responsibility for the regulatory aspect of food irradiation facility to good manufacturing practice. The Philippine Nuclear Research Institute (PNRI) should have the responsibility for the licensing of irradiation facilities as well as the operators of these facilities.

4. The following food items should be given clearance for irradiation and commercial sale.

| Food items | Purpose | Dose |
|---|---|---|
| onions, garlic and ginger | sprout | up to 0.15 kGy |
| mango and papaya | quarantine treatment | up to 0.35 kGy |
| corn, rice, copra, mungbean, coffee beans and dried fish | pest disinfestation | up to 0.75 kGy |
| spices | microbial control | up to 30.0 kGy |

5. BFAD, in consultation with DOST, should ensure a mechanism for continuous assessment and evaluation of the safety of irradiated foods as new data are generated.

In response to these recommendations, BFAD, which is mandated by law to be the lead food control agency, convened an interagency group to map out strategies for putting in place the regulations on food irradiation. At this point in time, BFAD is awaiting the recommendations of PNRI on the proposed Code of Practice for Food Irradiation based on the Codex document.

In addition to putting place appropriate regulations, there is a need for more studies to evaluate the commercial feasibility of food irradiation. The lack of supporting infrastructure, particularly transportation and storage facilities needed to move agricultural commodities from the farm to the irradiation plant has been a major deterrent to the commercial application of food irradiation rather than the anticipated restrictions brought about by regulation. Furthermore, the expected higher cost of irradiated commodities would render them unattractive to consumers.

The interest of the food industry lies mainly in products with high export potential such as mangoes, black pepper, dessicated coconut and frozen shrimps/ prawns. Regulatory and trade policies of importing countries on irradiated food would certainly influence the decision of the food industry to invest on a commercial irradiation facility.

# FOOD IRRADIATION CONTROL IN THAILAND

P. RANGSARITVUTIKUL
Thai Industrial Standards Institute,
Bangkok, Thailand

## Introduction

A considerable portion of food production of agriculture countries are lost as a result of inappropriate post-harvest systems, insects and other wastages and spoilage. It is now generally accepted that food irradiation is an efficient and effective technology in controlling and destroying disease - causing organisms and parasites in food. Its application improves shelf-life and marketability of food. Adoption of food irradiation offers the greatest prospects of benefit from reduction of post-harvest food losses, improvement of public health and facilitation of the international trade. However, there remain several constraints such as consumer acceptance, approval by the Governments and lack of information on food irradiation technology. Not only Governments should consider the introduction of regulatory procedures to control the processing and sale of irradiated food but also international trade would be facilitated by harmonization of national legislation for the control of food irradiation. When Governments introduce regulatory procedures for the control of food irradiation, they should ensure that they are consistent with internationally agreed principles as embodied in the Codex General Standard for Irradiated Foods and Associated Code of Practice, and the IAEA Basic Safety Standards for Radiation Protection and Regulations for the Safe Transport of Radioactive Material.

## Application of radiation technology in Thailand

In Thailand, radiation technology has been introduced and applied in many areas such as sterilization of medical products, food preservation and research/ development of irradiation technology in agricultural area.

At present, there are two radiation plants in Thailand. The first one is Gammatron Company Ltd. which is the only commercial radiation sterilization plant. It was established in 1982. The plant is situated in Nakron Pathom Province, the west of Bangkok. The registered capital is 75 million baht. The plant was designed with total source capacity of 500 kilocuries of $^{60}Co$ but only 150 kilocuries was loaded. The major production is radiation sterilization of some 30 medical supplied for domestic and foreign market. The other one is Thai Irradiation Centre (TIC) which is proceeded by the office of Atomic Energy for Peace under the Ministry of Science, Technology and Energy. TIC is located in Phathumthanee Province. The AIC proposed project was started in 1986 with the Canadian Government's assistance through the Canadian International Development Agency (CIDA) for the Expert Training Programme, equipment and technology transfer. The Thai Government has provided to this project their services, premises, building, equipment, facilities and personnel. The plant was designed with total source capacity of 3 millioncuries of $^{60}Co$ but only 400,000 curies was loaded.

So far, AIC has carried out the following responsibility:

- Irradiation of food commodity and non-food commodity
- Measurement of Absorbed Dose or Dosimetry system
- Testing the efficiency of the semi-industry food irradiation process
- Carrying out chemical, microbiology and entomology analysis sample before and after the irradiation process
- Consultation in Research and Development Project including

the demonstration of the operation and testing of the food irradiation

- Consultation in the application for a license for establishing a food irradiation plant and producing the irradiated food

- Providing information and document on the irradiation

- Providing training programme

**Government agencies concerning control of food irradiation**

Regarding the regulatory control of irradiated food in Thailand, at present, there are three main ministries involved in control of food irradiation process.

(i) Ministry of Public Health

The Food and Drug Administration of the Ministry of Public Health has the responsibility to ensure that food irradiation process, which included both licensing and registration of food irradiation premise as a food processing plant and also registration of irradiated foods in accordance with prescribed standards and labelling requirements, will be complied with the regulatory control in the Food Act.

(ii) Ministry of Industry

The Department of Industrial Works and the Office of National Codex Alimentarius Committee are both organizations under the Ministry of Industry which are involved in the corporation of food irradiation according to the Factory Act B.E. 2512. The applicant for any factory licence which uses machines, the output of which is more than 5 H.P. or is equivalent thereto, or employing 10 or more workers whether or not using machines, have to apply for the factory licence from the Department of Industrial Works.

Office of National Codex Alimentarius Committee is a division within Thai Industrial Standards Institute (TISI) to be responsible as a contact point of Codex Alimentarius Commission and has been appointed by the Cabinet to supervise the Codex matters in both policy and technical aspects. Thailand's procedure of Codex work is shown in Figure 1.

(iii) Ministry of Science, Technology and Energy

The Atomic Energy Commission for Peace of the Ministry of Science, Technology and Energy is assigned to carry out responsibility for application of nuclear energy, licensing and registration of irradiation facilities as well as regulating radiation dosimetry.

All concerned agencies in controlling of food irradiation is shown in Figure 2.

**Responsibility for the international food standards**

In October 1983, the Codex Alimentarius Commission adopted and published two documents: "Codex General Standard for Irradiated Foods" and "Recommended International Code of Practice for the Operation of Radiation Facilities Used for the Treatment of Foods".

The Codex General Standard have considered the recommendations and conclusions of internationally recognized food irradiation standards to be adopted by individual national governments. It recommends unconditional acceptance of foods irradiated up to a maximum average dose of 10 kGy using either radionuclide source ($^{60}Co$ or $^{137}Cs$) or machine sources (X-rays and electron accelerators).

In response to Codex General Standard for Irradiated Foods, the Government of Thailand, in July 1987, has accepted Codex General Standard for the Irradiated Foods in the form of Acceptance with Specified Deviation, i.e.

The labelling of irradiated food shall display in Thai but foreign languages are also allowed to be added. The following information shall be declared:

(a) Name and location of the head office of manufacturer and irradiation operator.

(b) Objective of irradiation using wording "Food which has been irradiated for the purpose of ....." (objective of irradiation to be filled in the blank).

(c) Date of irradiation (day, month and year). The symbol below, which means the food has been irradiated, shall be displayed on the label.

**Current national regulatory control situation**

The earliest regulation of irradiated food has been introduced since 1972. The purpose of the regulation is aimed to approve pre-marketing clearance of individual product on establishing special irradiated food standard itself. Subsequently, the policy was changed and developed to consist the international regulatory. Considering that the permission of irradiated food is recognized as a food processing method, the current regulation has been promulgated in 1986. This regulation is the Ministerial Notification No. 103 (B.E.2529) Re: Prescribing the Operation of Radiation, Facilities in the treatment of food. It includes the provisions on Code of Practices for Food Irradiation, types of ionizing radiation, kinds of foods, purpose of irradiation, limitation of maximum dose of irradiation, and labelling requirements. The purpose of this regulation is aimed at the effective control of good irradiation practices rather than just approving pre-marketing clearance of individual product. The nature of the process makes it difficult, at present, to determine the circumstances of irradiation by examination of the food.

Figure 3 shows the cooperation among the government agencies on the matter relating to food irradiation control in Thailand.

The notification is based on approaches or the principle elements for the control of irradiated foods which can be summarized as follows:

(a) Process Control: This includes the proper control of radiation sources, absorbed dose, measurement and the use of any facilities in the process, including staff or well-trained personnel. Correct dosimetry and dose distribution in the product helps to provide that the radiation treatment is both effective and legally complied.

(b) Food Hygiene: Good manufacturing practice should be applied to irradiated foods as any other foods. Raw materials used must be of good quality. It should be assured that there is no cross-contamination or recontamination of the product during the process and after the process. During storage, the product should be handled properly and orderly to prevent any contamination or mixing up between pre-irradiation product and post-irradiation product.

(c) Good Irradiation Practice: The facility used in food irradiation must be appropriate to ensure the required dose rate, application and provide suitable conditions, such as temperature.

(d) Product and Inventory Control: The incoming product and the outgoing irradiated product should be separated properly. Records showing the nature and kind of the product identifying mark, type of source, dosimetry used, the date of treatment, etc. should be kept properly for inspection or investigation.

(e) Labelling of the irradiated food should follow the requirements as set forth by the Ministerial Notification both for prepackaged products and bulk agricultural products destined to further processing.

The labelling of irradiated food shall display in Thai but foreign languages are also allowed to be added. The following shall be declared:

(a) Name and location of the head office of manufacturer and irradiation operator.

(b) Objective of irradiation using wording "Food which has been irradiated for the purpose of ..... (objective of irradiation to be filled in the blank)".

(c) Date of irradiation (day, month and year). The symbol which means the food has been irradiated shall be displayed on the label.

(d) The symbol which means the food has been irradiated as described in the Notification shall be displayed on the label.

## Conclusion

In order to facilitate international trade and harmonize the regulations on food irradiation, the consideration of Governments to establish the regulatory procedures for the control of the food irradiation process are very important and should be consistent with internationally agreed principles as embodied in the Codex General Standard for Irradiated Foods and associated Code of Practice. Governments should also provide clear and adequate information about food irradiation to the consumer because the terminology used for food irradiation is sometimes confused with that used to describe radioactive contamination. Since the technical and scientific information in the field of food irradiation vary widely from country to country, it would be necessary to the appropriate international organization or developed countries to provide technical and financial assistances for developing countries to initiate food irradiation technology.

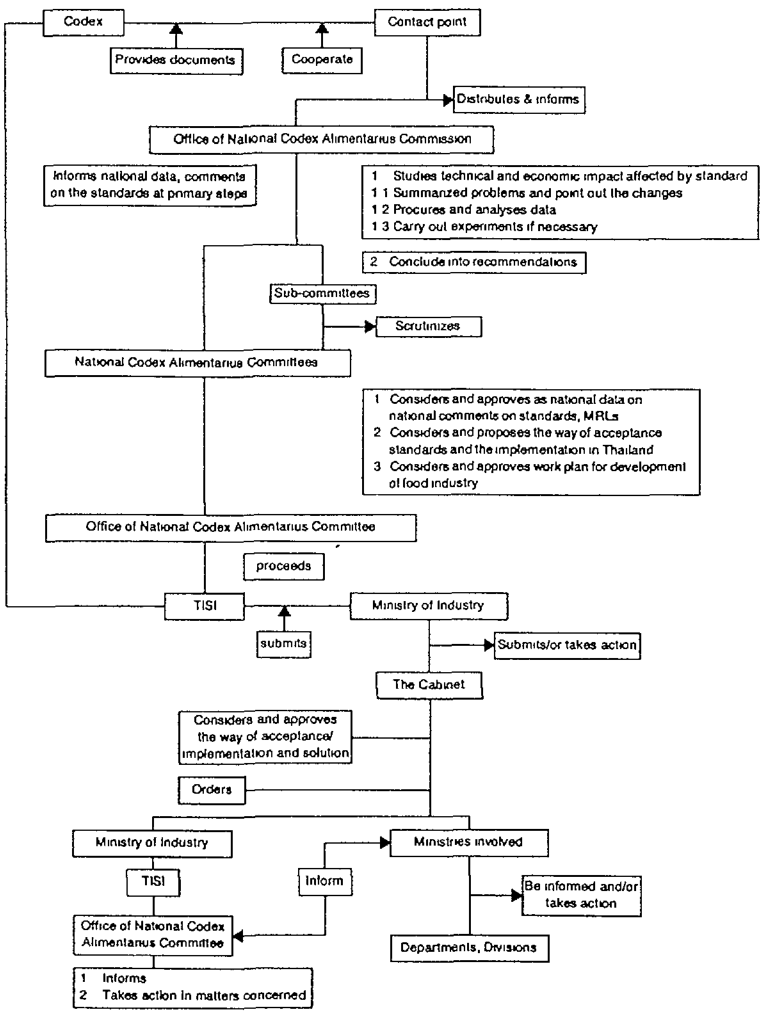



*FIG. 1. Thailand's procedure of Codex work.*

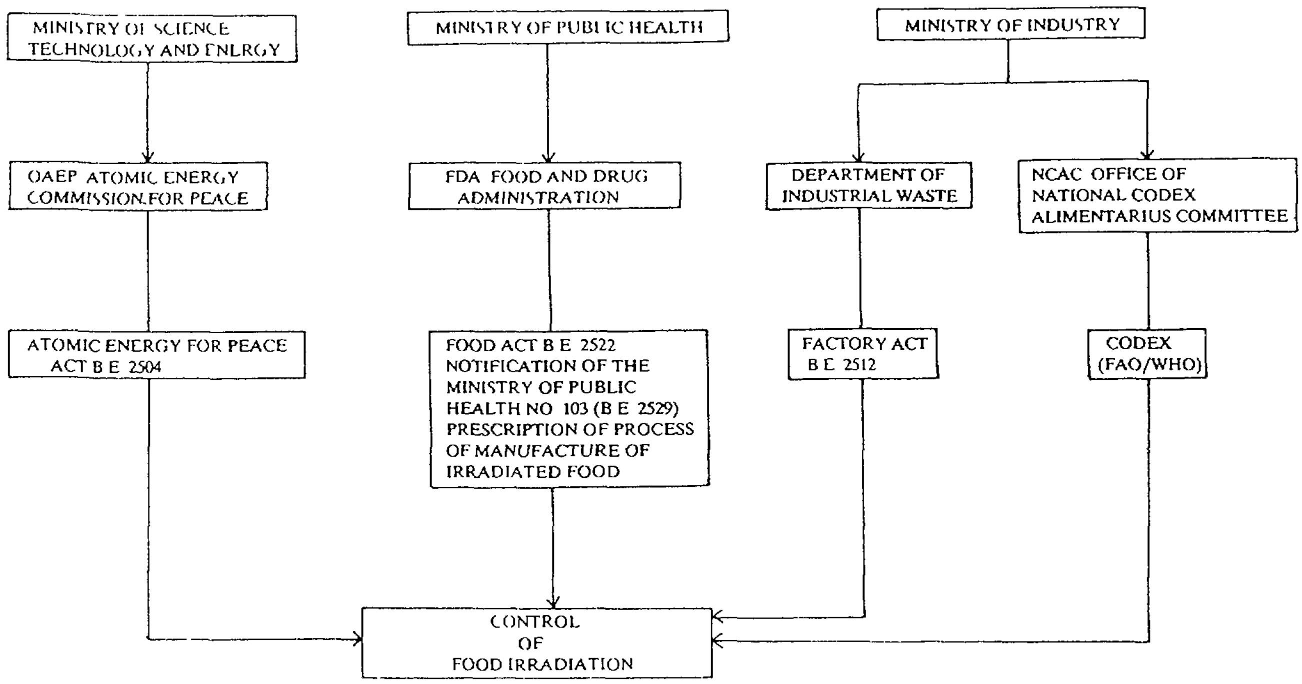
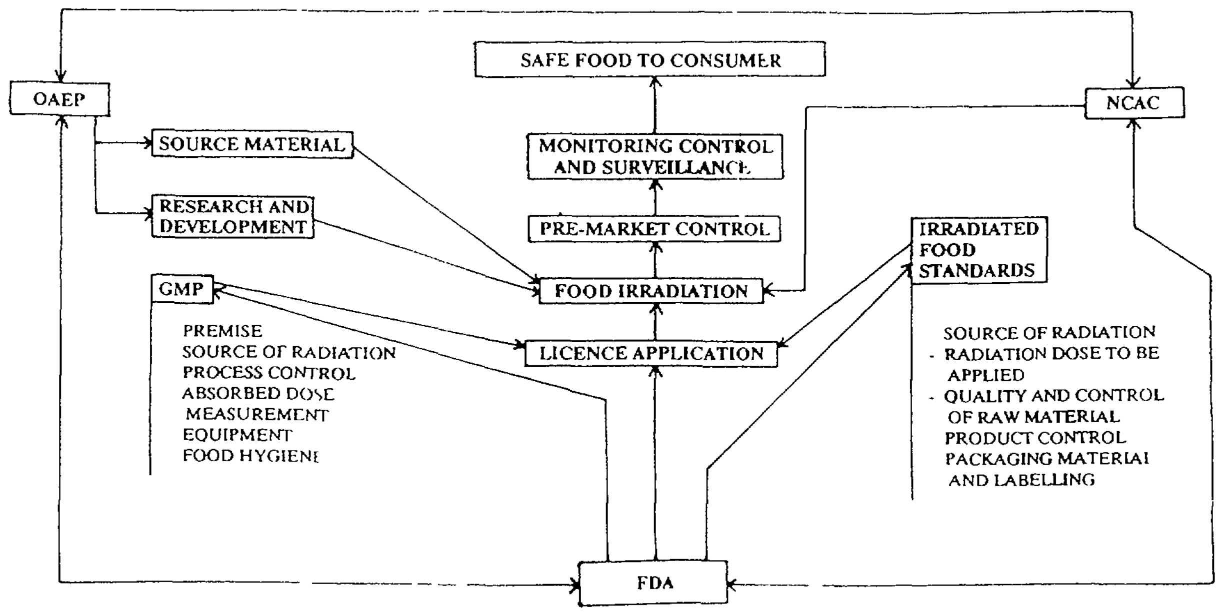



*FIG. 2. Government agencies concerned and their regulations.*




OAEP OFFICE OF ATOMIC ENERGY FOR PEACE
FDA FOOD AND DRUG ADMINISTRATION
NCAC OFFICE OF NATIONAL CODEX ALIMENTARIUS COMMITTEE

*FIG. 3. Cooperation among government agencies concerning food irradiation control in Thailand.*

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# THE SAFETY OF IRRADIATED FOOD IN VIET NAM

BUI MINH DUC, HUYNH HONG NGA
National Institute of Nutrition,
Hanoi, Viet Nam

As is well-known, food is one of the basic needs in human life. Therefore, food must be available in sufficient quantities with adequate nutritional content, be safe for consumption and not endanger the health of the population.

Food shortages and the probability of future famines are more likely in the developing countries than in industrialized societies. These problems are seen most frequently in the tropical regions of the world. In these areas, high temperatures, often associated with high humidities, create extreme problems for food storage. In some countries of the Region, grain and pulse losses due to insect and microbial infestations have been variously estimated as being between 20% and 50%.

Like many countries in Asia, Viet Nam has developed programmes for investigation, control and prevention of food contamination by spoilage agents and pathogens. The fight against food spoilage and foodborne diseases in Viet Nam is organized into three major approaches:

(a) Animals for food production should be pathogen free and carcasses should be of a good quality.

(b) Food storage and processing should utilize the most appropriate preservation technology e.g. chemical preservation and irradiation.

(c) Information and education of consumers and all those who handle or prepare food should be used to ensure that it is clearly understood that all efforts should and must be applied for the production of safe foods.

One of the beneficial applications of atomic energy is in preserving foods for an extended period and the use of irradiation has developed rapidly in Viet Nam and many other countries (as an alternative technique for food preservation). Effects of combining irradiation and other processes on the nutritional value of foods have been extensively studied both in Viet Nam and overseas.

It is well-known that some vitamins are partially destroyed by irradiation, that the loss increases with increasing radiation dose and that these losses can be ameliorated by irradiating at low temperature and in the absence of oxygen. However, the nutritive changes associated with food irradiation are difficult to detect. In 1980, a Joint FAO/IAEA/WHO Expert Committee on the Wholesomeness of Irradiated Food declared that the irradiation of any food up to an overall average dose of 10 kGy causes no toxicological hazard and introduces no special nutritional or microbiological problems.

In Viet Nam, the earliest published studies of irradiated foods were carried out in 1966 by Nguyen Manh Lien, Bui Minh Duc and their co-workers using gamma radiation to irradiate pork meat for the purpose of extending shelf-life and reducing the risk of foodborne pathogens. In 1968, Nguyen Huu Xy studied the use of gamma irradiation on batate for the inhibition of sprouting. Then, Bui Thi Yen and co-workers used a dose of 3-5 kGy to irradiate soyabeans, mungbeans, and dried squid for insect disinfestation. In later studies, Vo Hoang Quan and co-workers examined the effect of 50, 75 and 100 Gy doses on sprouting and quality of potatoes and onions. In these studies, he demonstrated the inhibition of sprouting for up to six months with onions and an ascorbic acid loss of 11-15% in potatoes while the loss was negligible in onions.

In November 1989, in response to requests from consumers to protect them from excessive use of food irradiation, special decrees for irradiated food were issued by the Ministry of Health as follows:

(a) It shall be provisionally permissible to use selected foods (Table 1) which have been subjected to gamma irradiation for the purposes of inhibition, sprouting and insect disinfestation. Food irradiation has the potential to reduce the incidence of foodborne disease through the reduction of pathogen contamination in foods, especially in solid foods. In other words, food irradiation can reduce post-harvest food losses in Viet Nam, and make available a larger quantity and a wider variety of foodstuffs for consumers.

(b) Food intended for treatment by irradiation should meet appropriate standards of safety and good hygiene conditions for processing Clearly, the important precaution here is to avoid excessive levels of bacteria in the food before irradiation.

(c) Acceptance of irradiated food by the consumer is a vital factor in the successful commercialization of the irradiation process and information dissemination can contribute to this · acceptance. Because the terminology used for food irradiation is sometimes confused with that used to describe radioactive contamination, the confusion can best be addressed by proper public information on food irradiation.

(d) The effectiveness of irradiation process depends on proper application of dose and its careful measurement. The dosimetry should be used in conjunction with national or international standards and thus provide an independent control of the process. These measurements should be used to ensure the correct operation of the process, and in August 1990, the Ministry of Health issued a decree that established the Adviser Council of Food Safety on Food Irradiation and Radionuclide Contamination. The Council includes three members from the National Institute of Atomic Energy and Centre Food Irradiation and the National Institute of Nutrition (NIN) is a permanent secretary of the Adviser Council. Hence, NIN will be able to establish a measure of the hygiene and safety of irradiated food in order to protect and improve public health.

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Table 1 Permissible dose of foods have been subjected to gamma radiation

| Product | Purpose of Irradiation | Sort of Clearance | Dose permitted (kGy) | Date of Approval |
|---|---|---|---|---|
| Potatoes | Inhibition of sprouting | Provisional | 0 15 | 3/2/89 to 3/2/91 |
| Onions | | | 0 1 | - |
| Garlic | - | | 0 1 | |
| Mungbean | Insect disinfestation | Experimented batches | 1 | 3/2/89 to 3/2/91 |
| Maize | | | 1 | |
| Spices and condiments | | | 1 | |
| Dried fish | | - | 1 | |

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## LIST OF PARTICIPANTS

| | | |
|---|---|---|
| Bangladesh | Mr A.S.M. Nurul Islam | Bangladesh Standards and Testing Institution<br>Agriculture and Food Division<br>116/A Tejgaon I/A.<br>Dhaka 1208 |
| China | Dr Kan Xuegui | Department of Health Inspection and Supervision<br>Ministry of Public Health<br>44 Houhai Beiyan<br>Beijing 100725 |
| | Mr Pan Xiumiao | Department of Basic Research and High Technology<br>State Science and Technology Commission<br>54 Sanlihe<br>Beijing 100862 |
| | Dr Song Yufang | Diivision of Radiation Health<br>Ministry of Public Health<br>44 Houhai Beiyan<br>Beijing 100725 |
| | Dr Xu Jin-kang | Toxicology Department<br>Institute of Food Safety Control and Inspection<br>7 Panjiayuan nanli Caoyan District<br>Beijing 100021 |
| | Mr Zhu Jiang | Office of IAEA Affairs<br>Ministry of Energy<br>Sanlihe, P.O. Box 2102<br>Beijing 100822 |
| Egypt | Dr Kamal El Din Hamza | Food Control and Food Safety Department<br>Ministry of Health<br>Cairo |
| Guam | Dr O.V. Natarajan | Division of Environmental Health<br>Department of Public Health and Social Services<br>P.O. Box 2816<br>Agana 96910 |
| Hong Kong (United Kingdom) | Dr Lo Wai-kee | (Occupational and Environmental Health)<br>Department of Health<br>Sunning Plaza, 9th Floor<br>10 Hysan Avenue, Causeway Bay |

| | | |
|---|---|---|
| India | Dr P.M. Nair | Food Technology & Enzyme Engineering Division<br>Bhabha Atomic Research Centre<br>Bombay 400 085 |
| Indonesia | Mrs Munsiah Maha | National Atomic Energy Agency<br>Centre for Applications of Isotopes and Radiation<br>Jl. Cinere Pasar Jumat Kotak Pos 2<br>Kebayoran Lama<br>Jakarta 12240 |
| | Dra (Mrs) S. Sitaba | Directorate of Food Control<br>Ministry of Health<br>Percetakan Negara 23<br>Jakarta 10556 |
| Japan | Dr T. Hayashi | Radiation Technology Laboratory<br>National Food Research Institute<br>Ministry of Agriculture, Forestry & Fisheries<br>Department of Food Distribution<br>Kannondai, Tsukuba, Ibaraki |
| Republic of Korea | Professor Jong Huh | Graduate School of Public Health<br>Seoul National University<br>Yeungun-dong, Jongro-ku<br>Seoul |
| Lao P.D.R. | Mr Ketsouvannasane Bounlonh | Food and Drug Commission Office<br>Ministry of Health<br>Vientiane |
| Malaysia | Mr Ahmad Nadzri Sulaiman | Jabatan Perkhidmatan Kesihatan Kelantan<br>Tingkat 5, Wisma Persekutuan<br>Jalan Bayam<br>15590 Kota Bharu<br>Kelantan |
| | Dr Anuar bin Ariffin | Food Quality Control Unit<br>Ministry of Health<br>Block E, 4th Floor Office Complex<br>Jalan Dungun<br>50490 Kuala Lumpur |
| | Dato' Dr Hajjah Azizan bte Aiyub Ghazali | Deputy Director of Health<br>Health Services Division<br>Ministry of Health<br>2nd Floor, Block E, Office Complex<br>Jalan Dungun<br>50490 Kuala Lumpur |

| | | |
|---|---|---|
| Malaysia (cont.) | Mr Che Azlan Shah b. Shahari | Pejabat Kesihatan Pelabuhan<br>Ministry of Health<br>Jalan Limbungan<br>42000 Port Klang<br>Selangor Darul Ehsan |
| | Dr Hajjah Harrison Aziz bt. Shahabuddin | Medical and Health Services Department<br>State of Selangor<br>4th Floor Bangunan Sultan Salahuddin Abdul Aziz Shah<br>40590 Shah Alam<br>Selangor Darul Ehsan |
| | Mr Haw Ai Beng | Medical and Health Services Department<br>State of Kedah Darulaman<br>1st Floor, Block A,<br>Bangunan Persekutuan<br>Jalan Sultan Badlishah<br>05590 Alor Star<br>Kedah |
| | Mr Ho Nee Yong | Medical and Health Services Department<br>State of Penang<br>37th Floor Komtar<br>10590 Penang |
| | Mr K.K. Khoo | De Smet (Malaysia) Sdn Bhd<br>49 Jalan SS15/4B<br>Subang Jaya<br>47500 Petaling Jaya<br>Selangor Darul Ehsan |
| | Mr A.C. Lam | Nestle (M) Sdn Bhd<br>Plaza Resources<br>4 Lorong Pesiaran Barat<br>46200 Petaling Jaya<br>Selangor Darul Ehsan |
| | Ms Judy C.L. Lim | De Smet (Malaysia) Sdn Bhd<br>49 Jalan SS15/4B<br>Subang Jaya<br>47500 Petaling Jaya<br>Selangor Darul Ehsan |
| | Mr S.C. Ng | Pepper Marketing Board<br>Tanah Putih<br>P.O. Box 1653<br>93916 Kuching<br>Sarawak |

| | | |
|---|---|---|
| Malaysia (cont.) | Ms Radziah Mohd. Daud | Standards and Industrial Research Institute of Malaysia (SIRIM)<br>P.O. Box 7035<br>40911 Shah Alam<br>Selangor Darul Ehsan |
| | Dr Rohani bte Ali | Food Quality Control Unit<br>Ministry of Health<br>Block E, 4th Floor Office Complex<br>Jalan Dungun<br>50490 Kuala Lumpur |
| | Ms M.C. Stephensons | Asean Plant Quarantine Centre and Training Institute (ASEAN Planti)<br>Post Bag 209, UPM Post<br>43400 Serdang<br>Selangor Darul Ehsan |
| | Mr Tan Kong Sing | Lever Brothers (M) Sdn Bhd<br>55 Jalan Bangsar<br>P.O. Box 11015<br>50990 Kuala Lumpur |
| | Mr Wang Yung Shyan | Lembaga Padi Dan Beras Negara<br>Tingkat 20, Bangunan Perkim<br>250-D Jalan Ipoh<br>P.O. Box 10108<br>50903 Kuala Lumpur |
| | Dr Yeoh Tow Kuang | Cold Storage (M) Berhad<br>Dairy & Beverage Division<br>Jalan 14/29<br>46100 Petaling Jaya<br>Selangor Darul Ehsan |
| | Ms Zainon Othman | Nuclear Energy Unit<br>Ministry of Science, Technology & the Environment<br>Kompleks PUSPATI, Bangi<br>43000 Kajang<br>Selangor Darul Ehsan |
| Nepal | Mr P.P. Manandhar | Quality Control Division<br>Central Food Research Laboratory<br>Babar Mahal<br>Kathmandu |
| Netherlands | Mr J.G. Leemhorst | Gammaster, b.v.<br>Postbus 600<br>NL-6710 BP Ede |
| Oman | Dr Suleiman bin Abdulla bin Mohamed Al-Awfy | Public Health Laboratories<br>Ministry of Health |

| | | |
|---|---|---|
| Papua New Guinea | Mr Igo Sere | (Food and Quarantine)<br>Department of Health<br>P.O. Box 3991<br>Boroko |
| Philippines | Dr Estrella F. Alabastro | Philippine Council for Industry and Energy Research & Development<br>Department of Science and Technology<br>Gen. Santos Avenue<br>Bicutan, Taguig<br>Metro Manila |
| | Mr O.R. Angeles | Bureau of Plant Industry<br>Plant Quarantine Service<br>692 San Andres St.,<br>Malate, Manila |
| | Ms Carmina J. Parce | Bureau of Food and Drugs<br>Department of Health<br>DOH Compound<br>Alabang, Muntinlupa<br>Metro Manila |
| Saudi Arabia | Mr Yackoub Abdallah Al Turky | Saudi Arabian Standards Organization<br>P.O. Box 3437<br>Riyadh |
| Singapore | Ms Seah Huay Leng | Food Control Department<br>Environment Building<br>40 Scotts Road<br>Singapore 0922 |
| Thailand | Dr C. Charoenpong | Food Standard Control Section<br>Food Control Division<br>Food and Drug Administration<br>Ministry of Public Health<br>Samsen Road<br>Bangkok 10200 |
| | Mr P. Rangsaritvutikul | Thai Industrial Standards Institute (TISI)<br>Rama VI Road, Ratchataywee<br>Bangkok 10400 |
| Vanuatu | Mr M. Varisipiti | Department of Health<br>Private Mail Bag 009<br>Port Vila |
| Viet Nam | Dr Bui Minh Duc | Department of Food Hygiene<br>National Institute of Nutrition<br>48 Tang Bat Ho Street<br>Hanoi |

| | | |
|---|---|---|
| | Mrs Huynh Hong Nga | Food Chemistry and Hygiene<br>National Institute of Nutrition<br>48 Tang Bat Ho Street<br>Hanoi |
| | Dr Vo Hoang Quan | Food Irradiation Laboratory<br>Vietnam National Atomic Energy Commission<br>Irradiation Centre<br>59 Ly Thuong Kiet Street<br>Hanoi |
| | Representatives | |
| IOCU | Dr J. Beishon | Association for Consumer Research<br>International Organization of Consumer Union (IOCU)<br>2 Marylebone Road<br>London NW1 2DF<br>United Kingdom |
| ITC | Mr B. Olsen | Market Development Section<br>Commodities & Agrobased Products<br>International Trade Centre (ITC)<br>UNCTAD/GATT<br>Palais des Nations<br>1211 Geneva 10<br>Switzerland |
| IPC | Dr Mohamed Ismail | International Pepper Community (IPC)<br>3rd Floor Wisma Bakrie<br>Jl. H.R. Rasuna Said Kav. B1<br>Kuningan, Jakarta Selatan 12920<br>Indonesia |
| | Observers | |
| Brazil | Mr Matias A.S. Vilhena | Brazilian Embassy<br>22 Persiaran Damansara Endah<br>Damansara Heights<br>50490 Kuala Lumpur<br>Malaysia |
| IUNS* | Dr Zawiah Hashim | Department of Food Science and Nutrition<br>Faculty of Life Sciences<br>Universiti Kebangsaan Malaysia<br>43600 Bangi<br>Selangor Darul Ehsan<br>Malaysia |

* International Union of Nutritional Sciences.

| | | |
|---|---|---|
| MSTE** | Mr Muhamad bin Lebai Juri | Nuclear Energy Unit<br>Ministry of Science, Technology and the Environment<br>Kompleks PUSPATI, Bangi<br>43000 Kajang<br>Selangor Darul Ehsan<br>Malaysia |
| | Secretariat | |
| WHO | Dr Paul Guo | WHO (PEPAS)<br>P.O. Box 12550<br>50782 Kuala Lumpur<br>Malaysia |
| | Mr A. Hazzard | WHO (PEPAS) |
| | Dr G. Moy | Food Safety<br>Division of Health Protection and Promotion<br>World Health Organization<br>CH-1211 Geneva 27<br>Switzerland |
| | Dr N. Tape<br>*(Consultant)* | 426 Halldon Place<br>Ottawa, Ontario<br>Canada |
| | Dr P. Pothisiri<br>*(Consultant)* | Ministry of Public Health<br>Devaves Palace<br>275 Samsen Road<br>Bangkok<br>Thailand |
| FAO/IAEA | Mr P. Loaharanu | Food Preservation Section<br>Joint FAO/IAEA Division of Nuclear Techniques in Food & Agriculture<br>International Atomic Energy Agency<br>Wagramerstrasse 5<br>P.O. Box 100<br>A-1400 Vienna<br>Austria |
| | Dr P. Roberts<br>*(Consultant)* | Nuclear Sciences Group<br>DSIR Physical Sciences<br>P.O. Box 31-312<br>Lower Hutt<br>New Zealand |

** Ministry of Science, Technology and the Environment, Malaysia