Safeguarding Our Harvests

Assessing the Use of Irradiation in Facilitating the Achievement of Food Security Goals

International Consultative Group on Food Irradiation

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Assessing the Use of Irradiation in Facilitating the Achievement of Food Security Goals in Developing Countries

International Consultative Group on Food Irradiation (ICGFI)

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Foreword

The International Consultative Group on Food Irradiation (ICGFI) was established on 9 May 1984 under the aegis of FAO, IAEA and WHO. ICGFI is composed of experts and other representatives designated by governments which have accepted the terms of the "Declaration" establishing ICGFI and have pledged to make voluntary contributions, in cash or in kind, to carry out the activities of ICGFI.

The functions of ICGFI are as follows:

- ❒ to evaluate global developments in the field of food irradiation;
- ❒ to provide a focal point of advice on the application of food irradiation to Member States and the Organizations; and
- ❒ to furnish information as required, through the Organizations, to the Joint FAO/IAEA/WHO Expert Committee on the Wholesomeness of Irradiated Food, and the Codex Alimentarius Commission.

As of May 1998, the following countries are members of ICGFI:

Argentina, Australia, Bangladesh, Belgium, Brazil, Bulgaria, Canada, Chile, Costa Rica, Côte d'Ivoire, Croatia, Cuba, Czech Republic, Ecuador, Egypt, France, Germany, Ghana, Greece, Hungary, India, Indonesia, Iraq, Israel, Italy, Republic of Korea, Malaysia, Mexico, Morocco, Netherlands, New Zealand, Pakistan, People's Republic of China, Peru, Philippines, Poland, Portugal, South Africa, Syrian Arab Republic, Thailand, Tunisia, Turkey, Ukraine, United Kingdom, United States of America, Viet Nam, and Yugoslavia.

The 11th Annual Meeting of ICGFI held in Bali, Indonesia, November 1994 requested that a comprehensive Programme of Work and Budget of ICGFI for 1996-98 be developed to facilitate the consideration of ICGFI member governments on the extension of its mandate. A Working Group was therefore convened for this purpose in Vienna in April 1995 which recommended, among other things, that urgent consideration be given to the development of ICGFI documents which would clearly define the role that irradiation can play in achieving the general policy goals endorsed by Member States of various UN Organizations. Five such policy documents in the areas of Food Safety, Food Security, Trade Development, Environment, and Energy Conservation were recommended by the Working Group. However, in view of the financial constraints, the 12th ICGFI Annual Meeting held in Vienna, November 1995, decided to prepare only the first three such documents.

This publication was prepared by Dr. Norman W. Tape, formerly, Director of Food Research Institute, Agricultural Canada, Ottawa, on behalf of ICGFI. It clearly explains the role of irradiation in achieving the food security goals of governments, especially those of developing countries. After undergoing peer review and comments by national contact points of ICGFI and subsequent revisions by the author, this document was approved for publication as one of the information documents by the 14th ICGFI Meeting. The ICGFI Secretariat gratefully acknowledge the valuable contribution of Dr. Tape and those who were involved in reviewing this document. This document was professionally edited by Mr. R. Peniston-Bird, a former editor of the IAEA.

Executive Summary

Global attention to food insecurity and malnutrition began in the 1930s at the League of Nations and eventually led to the establishment of the Food and Agriculture Organization in October 1945, eight days before the United Nations itself came into existence.

Safeguarding our harvests from pests and spoilage is an essential, yet frequently neglected, component of food security. Inadequate control of post-harvest losses leads to a significant loss of valuable produce; waste of production resources (water, land, labour, etc.); rejection of products in domestic and export markets; and higher prices for those who can least afford it.

Technologies used to control post-harvest losses must fit into existing social and marketing systems, be cost effective and provide better-quality, safe products for consumers. Some of our current technical capability is being eroded owing to toxicological, occupational and environmental concerns. In addition, consumers are seeking 'clean' food, with minimal use of additives and little or no pesticide residue.

Irradiation is an effective, broad-spectrum, residue-free, mature technology. It controls insect infestation, inhibits the germination of root crops, and prolongs the shelf-life of perishable produce. International standards to ensure the safety of irradiated products and to facilitate trade have been recommended by the Codex Alimentarius Commission which is recognized by the World Trade Organization (WTO). Good Irradiation Practices (GIPs) for a broad range of applications have been developed and widely disseminated by the International Consultative Group on Food Irradiation (ICGFI). Expertise in irradiation processing exists in a network of centres around the world, many of them in developing countries. At present, 41 national governments have regulations which permit commercial applications of food irradiation.

Today, there is increasingly less polarity in public views of food irradiation. Regulatory approval and commercial use of irradiation can now be assessed on merit and business realities. Commercialization will be based on effectiveness, investment costs, adaptability to existing social and marketing systems and the overall net benefit to producers, marketers and consumers through increased sales, better quality, longer shelf-life and lower prices.

Irradiation can play an important role in achieving the food security goals of developing countries. In addition, it can serve the mutual interests of developing countries and more industrialized societies by assisting the expansion of agricultural trade. Putting an end to food insecurity requires a family of integrated actions. Concurrent attention to increased production and safeguarding harvests is a vital part of any action plan to achieve food security.

The purpose of this document is to assess the utility of irradiation in facilitating the achievement of policy goals on food security in developing countries

The Food Security Vision

The worry of providing an adequate and nutritious food supply has been a concern of families, peoples and nations from the earliest times. This apprehension led not only to increased production, but also to preserving our harvests by developing storage methods and facilities, dried foods, fermented beverages, smoked meats, salted fish and eventually to pasteurization, canning, freezing and advanced dehydration techniques.

Global consideration of food insecurity began in the 1930s at the League of Nations with Stanley Bruce's proposal to "marry health and agriculture". This concept of integrating health and agricultural considerations led to the 'Freedom From Want of Food' and 'Health For Everybody in All Parts of the World' proposals adopted at the Hot Springs conference in 1943 and eventually to the establishment of a permanent organization for food and agriculture, the FAO, in October 1945, eight days before the United Nations organization itself came into existence.

Actions required to eliminate hunger and malnutrition were addressed at the World Food Congresses in 1963 and 1970, and subsequently at a World Food Summit in 1974.

A second World Food Summit, in 1996, sought a renewed commitment to 'Food For All' by Heads of States and Governments. The Summit addressed the need for a global commitment and action to redress human society's most basic problem - food insecurity.

Addressing the Vision

Food security is a difficult concept to grasp and address because it involves the integration of several broad, global dimensions - economic, social, political, environmental and trade. Moreover, each dimension has formidable, sometimes competing, objectives - development, sustainability, health, equity, access, efficiency, etc. In addition, different approaches to address the 'food security vision' vie for priority attention and scarce resources - elimination of poverty, population control, increasing agricultural production and productivity, building food reserves and avoiding waste. The maintenance of buffer stocks, particularly of staple foods, is a high priority in developing countries not only to stabilize food prices but also to meet shortfalls due to crop failure.

Safeguarding Our Harvests - a Neglected Priority

Safeguarding our harvests through efficient storage, processing, distribution and marketing has been largely neglected by many countries and international organizations. Food security action plans have traditionally given the highest priority and the majority of resources to increasing agricultural production and productivity. Complementary attention to increased efficiency in product utilization has been given little consideration.

The neglect of the post-harvest sector, a major and growing part of the food chain, is difficult to explain. It is equivalent to giving priority to iron ore and steel production, when consumers want useful tools, machines and appliances. Only recently have some agriculture ministries and international organizations recognized the impact of urbanization on the food system and the significant contribution of an efficient post-harvest sector to the overall economy, employment and the assurance of an adequate, nutritious food supply.

Protecting our harvests should receive a higher priority for several reasons:

Losses are significant

Post-harvest losses in quantity and quality of produce occur in all societies. Unfortunately, they tend to be highest in those areas where the need is the greatest. Conservative estimates of losses indicate the average loss of cereals and legumes is above 10%. For more perishable produce the losses exceed 20% of roots and tubers, and 30% of fruits and vegetables. Reported losses for individual crops can rise to well over 60%. These losses normally occur during storage, transport and marketing. A 10% loss in a staple crop is significant since it is equivalent to the amount normally purchased by government stabilization boards to protect against future crop failures and to stabilize prices for producers and consumers. Satisfactory long term storage of staple crops may be at risk as some traditional fumigants are phased out.

Production resources are wasted

Post-harvest losses waste scarce production resources, such as water, land and labour. Moreover, the waste of production resources can negatively affect agriculture sustainability - e.g. through land erosion, soil degradation and increased applications of pesticides and fertilizers. These wasted resources would be better used to produce crops for export or to diversify local diets.

Post-harvest losses are costly to all

The value of agriculture and fisheries products doubles between harvest and retail. Therefore, significant losses in harvested produce decrease the returns to producers, distributors and marketers and raise consumer prices. A more efficient system would reduce costs and therefore lower prices to the consumer. The key questions, of course, are the size of the investment required to achieve the improved efficiencies and the extent of benefits to producers, distributors, marketers and consumers.

Neglect has negative consequences

The post-harvest sector needs supportive government policies, a meaningful level of R&D effort, useful market information and effective extension services in order to foster investment in developing more efficient stor-

age, processing, distribution and marketing systems. Neglect of these development prerequisites has the following implications:

- ❒ Pests eat first at our 'Food For All' table.
- ❒ costly rejections of agriculture and fisheries products, particularly by export and tourism markets, but also by consumers in domestic markets.
- ❒ higher prices for those who can least afford an adequate, safe and nutritious food supply.
- ❒ adulteration of staple foods by unscrupulous marketers seeking prolonged shelf-life for their products.
- ❒ smuggling of high demand fruits and vegetables may disseminate harmful pests.
- ❒ the rubbish bin becomes a major consumer of food.

The causes of waste are the direct consumption of food by insects, rodents and birds; microbial contamination leading to rotting, discoloration, 'off odours' and sometimes toxic substances; excessive or poor handling leading to bruising, cuts and subsequent trimming; inadequate temperature control leading to physiological spoilage; the lack of cost effective technology because of the unavailability of financial resources; and the lack of knowledge by managers and operators of storage, distribution and processing facilities.

The technical options available to reduce post-harvest losses are:

- ❒ to provide physical barriers (storage buildings and/or packaging) to control infestation and environmental degradation;
- ❒ to provide low temperature and atmospheric control to inhibit pests and control product maturation;
- ❒ to use chemicals to control infestations, microbial contamination or sprouting; and
- ❒ to apply a treatment to ensure the elimination of pests before shipment and/or storage, using heat, freezing, chemicals, irradiation or various combinations of these treatments.

In view of the spectacular technological advances which have led to increased agricultural production, a similar feat in safeguarding our harvests is surely within our means and grasp.

Issues affecting current and new technologies

Chemical based treatments are frequently preferred over physical barriers and temperature controls because they are generally more convenient, possibly less expensive and do not require well-trained personnel. However, our heavy reliance on chemical based technologies is being challenged and, to compound the problem, new alternative technologies are often difficult to introduce. The pressures on existing and new treatments for protecting our harvested produce are as follows:

Safety Concerns

Toxicological and occupational safety reviews have led to the banning or phasing out of some chemical treatments, e.g., ethylene dibromide (EDB) was banned in the 1980s as a fumigant for fresh fruits and vegetables. Ethylene oxide (ETO) is banned in most major food importing countries and is being reviewed in others as a decontamination fumigant for spices, cocoa beans and grains. Phosphine, the only fumigant (other than methyl bromide) widely registered and used, is toxic, flammable, reacts with some metals, and is relatively slow acting.

Environmental Concerns

Methyl Bromide (MB), the most extensively used fumigant for food and other agricultural applications, may suffer the same fate as EDB. Methyl bromide is listed under the 1991 Montreal Protocol as an ozone-depleting substance and is planned to be phased out of production and use in industrialized countries and its utilization will be frozen in developing countries in the next few years. An extensive search for alternatives to MB is under way, including the consideration of irradiation for controlling insect infestation and quarantine pest problems.

Insect resistance

Resistance to phosphine and some other insecticides is an emerging problem.

Consumer Acceptance

New technologies, such as food irradiation, the use of growth hormones and transgenic plants, are difficult to introduce owing to consumer confusion regarding their safety, benefits and limitations. Perceived public concern, rallied by advocacy groups and the media, has delayed regulatory approval and the commercial use of food irradiation. However, numerous market trials have demonstrated that consumer reluctance decreases remarkably when consumers have the opportunity to purchase irradiated foods and experience the benefits.

Regulatory acceptance

Government approval of a new treatment requires extensive technical documentation to demonstrate efficacy and safety, particularly when political pressures are exerted. These reviews may be lengthy and costly.

These technical and market issues are vital to all countries, particularly developing countries interested in meeting the growing demands of affluent urban markets for a wide variety of fresh products, particularly fruits and vegetables, all the year round. Improved packaging, rapid air freight and better knowledge of optimum handling conditions support the expansion of this growing international market. In addition, buffer stocks of staple foods are needed to provide a secure food supply to growing rural and urban populations in the event of crop failures due to natural and man-made disasters. The need to find economic alternatives to chemical treatments has become a priority to many governments and international plant protection organizations. Irradiation, a physical treatment, is an alternative phytosanitary measure being actively considered.

Considering Irradiation

All food preservation technologies aim to reduce losses, control foodborne pests and diseases, and retain original quality and nutritive value. No single technology is suitable for all applications. All preservation methods will reduce product quality in some applications. Each technology has particular advantages and limitations, and may act in a complementary way with other technologies. Identifying the comparative advantages of competing technologies or combinations of treatments is the challenge for technologists, marketers and consumers.

Irradiation has some valuable features compared to other preservation technologies:

- ❒ it is a physical, not chemical, process which leaves no residue;
- ❒ it preserves solid foods, as pasteurization preserves liquid products;
- ❒ it is a 'cold' process, applicable to chilled and frozen foods;
- ❒ it is a relatively low-cost, broad-spectrum, low-energy alternative to canning, freezing, and dehydration;
- ❒ it can complement other technologies, particularly refrigeration; and
- ❒ it is particularly efficient for high throughput, free flowing products, such as grains.

Irradiation has been proven effective and safe to use in several commercial applications, e.g. delaying the germination of root crops; delaying the ripening of fruits and vegetables; controlling insect infestation in cereals and pulses; and as a treatment for quarantine pest problems. These 'food security' applications are achieved with low doses of irradiation; many require less than 1 kiloGray (kGy).

Many national governments, 41 at present, have regulations which permit commercial applications of food irradiation. Expertise in irradiation processing exists in a network of centres around the world, many of them in developing countries. In addition, international standards for irradiation and the operation of irradiation facilities were established in 1983 by the Codex Alimentarius Commission. The Codex General Standard for Irradiated Foods recognizes the safety and effectiveness of food treatments up to an overall dose of 10 kGy. Standards and related texts established by the Codex Alimentarius Commission are recognized by the World Trade Organization (WTO) in the Agreement on the Application of Sanitary and Phytosanitary Measures.

The Codex standards have been and will be used by WTO as an instrument to settle trade disputes. Although countries may impose more stringent standards than provided by the Codex, there must be a scientific justification for any restriction to trade.

The World Health Organization (WHO) views irradiation as a process which has the potential to increase the supply of safe food, and thus contribute to improved public health. The Food and Agriculture Organization (FAO) sees food irradiation as a process to reduce food losses and facilitate trade. It would appear difficult for a country to ban the importation of irradiated foods without the risk of a challenge.

Applying irradiation

Commercial application of irradiation technology requires several different assessments in order to determine the suitability of its use and to justify the investment and operating costs.

The following checklist describes the range of considerations:

Range of commodities for treatment

Extensive research over four decades has documented the effectiveness and safety of irradiation treatments for a broad range of commodities:

- ❒ root crops: control of sprouting and germination of potatoes, yams, onions, garlic and ginger roots;
- ❒ grains and pulses: kills or sterilizes the common insect pests;
- ❒ dried fish, fruits, vegetables and nuts: insect disinfestation;
- ❒ fresh fruits and vegetables: extends shelf-life by delaying ripening and prevents importation of harmful insects by pre-shipment and quarantine treatments; and
- ❒ perishable foods: extends shelf-life by control of microbial spoilage of fruits, vegetables, meats, poultry and seafood.

Technical considerations

The essential requirements are knowledge of the minimum effective dose, the maximum dose above which quality is impaired and dose uniformity tolerance. Storage conditions before and after treatment must also be defined, as well as labelling requirements and quality assurance needs (e.g. dose measurement and control). Re-irradiation of products of low moisture content (e.g. grain, nuts) is allowed by the Codex General Standard. However, every effort should be made to provide protection against insect reinfestation of such products.

Infrastructure requirements

These requirements include regulatory approval for commercial application of irradiated foods in domestic or export markets; approval from a national Atomic Energy Control Board for facility location, design, construction and certification for use; well-trained managers, operators and staff; product storage capability, both pre- and post-treatment; and good transport accessibility. Good Irradiation Practices (GIPs), published by the International Consultative Group on Food Irradiation (ICGFI), should be used by authorizing agencies and commercial operators of food irradiators. Process control schools organized by ICGFI are available for the training of managers, operators and inspectors of food irradiation facilities.

Government approval, particularly by importing countries, requires extensive technical documentation and can be a major impediment to commercialization. The harmonization of regulations by trading countries is necessary to facilitate trade by minimizing the use of non-tariff barriers based on human, animal and plant health risks.

Cost considerations

The major factors influencing the economics of food irradiation are as follows:

- ❒ Irradiator design parameters such as the applied dose; packing density of the products; handling conditions (dry ver-

sus perishable products); dose uniformity; and throughput. Post-harvest treatments to enhance food security typically use a radiation dose below 1 kGy.

- ❒ Capital costs consisting of the irradiator, Co60, land and warehouse capacity.

- ❒ Operating costs such as salaries, utilities, replenishment of Co60, amortization of land and facility, taxes, etc.

In view of the significant influence of local conditions, the crops being treated and the numerous other variables affecting the economics of irradiation treatment, it is difficult to provide cost estimates for food security applications (e.g. sprout inhibition in root crops, insect disinfestation in grains). However, to provide a general indication of commercial processing costs (e.g. throughput more than 60 000 t/a) at a treatment dosage up to 1 kGy, the cost would be US $1-3 per tonne.

The cost of irradiation may be discounted by the cost of the alternative process which irradiation replaces. Therefore, the actual cost of irradiating fresh fruit for quarantine purposes or the longer term storage of grain would be the increased cost, if any, over the current cost of fumigation by MB or phosphine. In some applications irradiation may be less expensive and produce a better quality product than alternative treatments, such as hot water or vapour heat-treated fruits. An additional offsetting saving may be realized in treatments which prolong shelf-life or reduce waste, thus increasing the volume of saleable product and profits.

Electron beam irradiators may have economic advantages over gamma irradiators where product throughput is large, the particle size or thickness of product being treated is small, and where continuous treatment is possible by integrating the irradiator into the production line. As a result, they may be more efficient than gamma irradiators for treating large volumes of domestic or imported grains. These machine-type irradiators, based on electron acceleration rather than radionuclides, may not require as many regulatory approvals.

In each particular application, the bottom line is the overall net benefit; i.e., will investment costs be surpassed by increased revenue from more products being sold because of reduced waste and enhanced market value (e.g. higher quality, residue-free, safer products).

Social and logistic considerations

In developing countries, the impact of a new technology on the existing storage, distribution and marketing system is a vital consideration. In many developing countries agricultural production is decentralized and the transportation system cannot assemble large quantities of harvested crops for storage. However, in situations where large quantities are brought together either for storage or export, irradiation treatment may be realistic. For example, many governments maintain stocks of grain and other staples for a 9-12 month storage period as a protection against future crop failure and to stabilize farm and consumer prices. Quantities stored may be in the order of 10% of total crop production. Treatment of these stabilization stocks should be considered. In addition, irradiation may well be advantageous for the treatment of crops assembled for export and requiring an effective quarantine treatment to eradicate product-borne pests. In view of the possible loss of MB as a fumigant, all practical alternative treatments should be explored.

Consumer acceptance

A more open, positive attitude is emerging in many countries regarding the commercial application of food irradiation. There are several reasons for this change:

- ❒ the general public is becoming more aware of the need to produce, protect and market food in ways which mini-

mize food safety and environmental risks, and prefers control by residue-free measures;

- ❒ governments are giving a high priority to finding alternatives to hazardous chemicals (e.g. MB) and reducing public health risks (e.g. by integrating Good Manufacturing Practices and the Hazard Analysis Critical Control Point concept into food control regulations);

- ❒ the media are giving irradiation a more balanced coverage and less consideration to unsubstantiated negative views;

- ❒ retail marketing of irradiated food continues to demonstrate positive acceptance in developed and developing countries when consumers have the opportunity to make up their own minds.

In summary, there is less polarity in views about irradiation and a greater willingness to consider commercial applications based on merit.

A good example of government leadership is the development of regulatory policies for the use of irradiation as a phytosanitary treatment by the Animal and Plant Health Inspection Service (APHIS) of the US Department of Agriculture (USDA). The North American Plant Protection Organization (NAPPO) has issued a phytosanitary standard based on the APHIS document. This work led to the adoption in 1996 by the USA of an irradiation regulation to allow the treatment of certain Hawaiian fruits (e.g. papaya, carambola, lychee) prior to marketing in the mainland USA.

Conclusions

Irradiation, alone or in combination with other preservation technologies, can facilitate the goals of food security in developing countries and, in addition, be mutually beneficial to developing countries and more industrialized societies by the expansion of agricultural trade.

What is the rationale for this positive assessment? The key points are:

Irradiation is effective

Research, pilot trials, market tests, and, in many cases, commercial use, have demonstrated the effectiveness of irradiation in controlling a wide variety of pests and spoilage organisms in durable and perishable commodities, as well as prolonging the shelf-life of several root crops and fresh fruit and vegetables. The limitations of irradiation technology are also well known.

Commercial experience

Irradiation has become a mature process with over 20 years of commercial experience behind it. Technology, equipment and marketing expertise derived from commercial practice are available. Training in the operation and inspection of commercial irradiators is also available at the Food Irradiation Process Control Schools organized by ICGFI.

Regulatory support

The foundation for national regulations was established by the 1983 Codex international standards and strengthened by WTO recognition of the Codex standards in 1993. Government initiatives in the 1990s have led to a significant expansion of product approvals for commercial use, as well as active consideration of irradiation as a treatment for plant pests of quarantine significance. In addition, the Association of South-East Asian Nations (ASEAN) is in the process of reaching a unified regulatory position on food irradiation. The European Union (EU) is initiating a similar process.

Alternative technologies are needed

Some traditional chemical based treatments have been banned and others are likely to be banned in future for health, environmental or occupational safety reasons. Economic alternatives, particularly physical methods, are needed. Irradiation is a broad-spectrum, residue-free alternative, requiring only low doses, using little energy, to reduce post-harvest losses effectively.

Offsetting savings

The costs of irradiation may be discounted by the cost of the process it replaces (e.g. fumigation), or by better quality products (e.g. compared to hot water treatment), or increased profits from higher sales (e.g. due to waste reduction).

Assessment on merit

Commercialization can now be based primarily on the technical, financial and marketing merits of irradiation technology. There is less polarity in views on irradiation and perceptions of public concern in many countries. Commercial decisions, by government agencies or the private sector, will be based on the investment requirement; on logistic and transport considerations; on the extent of regulatory approvals and international harmonization of these;

and on market assessments of net benefits to producers, marketers and consumers.

Putting an end to food insecurity requires a family of integrated actions. Concurrent attention to increased production and safeguarding harvests is a vital part of any plan of action to achieve food security. Food irradiation can play an important role in achieving food security in developing countries, as well as serving the mutual interests of all nations by assisting in the expansion of agricultural trade.

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