IRRADIATED FOODS

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EXECUTIVE SUMMARY

- An overwhelming body of scientific data from around the world indicates that irradiated food, as approved by the United States Food and Drug Administration (FDA), is safe, nutritious and wholesome.
- As of November 1995, and dating back to 1958, food irradiation has been approved by 40 countries. This food preservation process has been adopted successfully in 27 countries, including such technologically advanced countries as Canada, France, Japan, The Netherlands, Belgium and South Africa.
- Commercial adoption of food irradiation is expected to reduce the presence of foodborne disease–causing microbes and parasites and thus also reduce the incidence of diseases caused by these pathogens.
- The United States Department of Agriculture estimates that the American consumer will receive approximately $2 in benefits such as reduced spoilage and less illness for each $1 spent on food irradiation.
- Irradiation has been studied more extensively than any other food preservation process, including canning, freezing, dehydration and chemical additives. Health authorities worldwide have based their approvals of irradiation on the results of sound scientific research.
- When food has been irradiated under FDA-approved conditions, no unique chemical (radiolytic) products have been detected.
- Cobalt 60 (the preferred irradiation source) has a relatively short half-life of about five years, so it

decays quickly when its useful life is over. When machine sources of irradiation (high-energy electrons and X rays) are used, no radioactive waste is produced at all. There is no link between irradiated food and nuclear-weapons production.

- Food irradiation facilities and transport of radioactive fuel must meet stringent federal and state regulations. The industry has an excellent safety record.
- Irradiation has been approved by the United States for controlling insects in wheat and flour (1963), inhibiting sprouting in potatoes (1964), controlling contamination in dried spices and dehydrated vegetable seasonings (1983), destroying *trichina* in pork (1985), delaying ripening of fruit and disinfesting fruits and vegetables of insects (1986) and controlling foodborne pathogens in poultry (1992).
- The FDA is currently evaluating a 1994 petition for destroying harmful bacteria in beef, veal and other red meats. Petitions for irradiating eggs and fish are expected to be submitted to the FDA in the near future.
- A Chicago-area supermarket has been offering irradiated fresh produce and raw chicken to its customers for over two years. All packages carry the irradiation symbol and the statement "irradiated for safety and freshness."
- The American Council on Science and Health supports *informational*—not warning—labeling requirements for irradiated food as approved by the FDA. We encourage firms to consider marketing irradiated food and to inform consumers that irradiated food can mean safer food.

INTRODUCTION

Why irradiate foods? Because irradiation can improve the quality, variety and safety of foods for the consumer. It can help reduce the incidence of foodborne illnesses. Its increased use in the United States could even increase U.S. food exports.

Keeping our food supply safe and abundant is a challenging task. Insects and other pests compete with us for food. Microorganisms can spoil food and make it unsafe to eat. Some foods are seasonal and highly perishable; unless safe means of processing and storing them are available, waste and/or periodic shortages can occur.

For centuries, great efforts have been devoted to finding ways of preserving food and protecting it from microorganisms, insects and other pests. Drying was one of the first techniques developed. Heating, fermenting, salting and smoking also have long histories of use in food preservation. Later inventions include the use of preservatives other than salt, canning, freezing, refrigeration and crop-protecting chemicals. All have played a part in improving the quality, quantity and safety of our food supply, protecting it against destruction, microbial contamination and spoilage.

Another technique, irradiation, may soon join this arsenal of food-protection methods. Irradiation is already being used to a very limited extent in the United States, and it has had wider application overseas. This process, which has been studied by scientists for almost 50 years, is very promising; yet, relatively few American consumers have heard of it, and some of those who have may be concerned about the nutritional quality and safety of foods treated in this unfamiliar way.

The American Council on Science and Health (ACSH) has prepared this booklet to introduce consumers to the process of food irradiation and to answer some common questions about the quality and safety of irradiated foods.

BACKGROUND

What Is Food Irradiation?

Food irradiation is the treatment of foods by subjecting them to ionizing radiation, also called ionizing energy. The radiation used in the process comes either from radioactive isotopes of cobalt or cesium or from devices that produce controlled amounts of high-energy electrons,* gamma rays* or X rays.* The process does not and cannot make the food radioactive.

What Kind of Radiation Would Be Used to Treat Foods?

The radiation used to treat foods is called “ionizing radiation” because it produces ions—electrically charged particles. Ionizing radiation—including X rays, gamma rays and beams of high-energy electrons produced by electron accelerators—has a higher energy than other, nonionizing radiation such as visible light, television waves, radio waves and microwaves.

Two radiation sources are practical for food treatment. The first is a tightly sealed metal container of radioactive elements—cobalt 60 or cesium 137—that produce gamma rays. The rays are directed onto the food being irradiated, with the food itself never being touched by the cobalt or cesium. The second type of radiation source is a machine that produces X rays and high-energy electrons. Neither of these sources has enough energy to make the irradiated foods radioactive.

What Can Irradiation Do?

Irradiation has a number of uses in food processing, most of which improve the safety and quality or prolong the useful life of foods. Different doses of radiation are used for different purposes, as is shown in Table 1.

TABLE 1: Applications of Food Irradiation

Type of Food	Radiation Dose (in kGy*)	Effect of Treatment
Meat, poultry, fish, shellfish, some product can be vegetables, baked goods, prepared perature without foods	20–71	Sterilization. Treated stored at room tem- spoilage.
Spices and other seasonings microorganisms and chemicals used for	Up to maximum of 30	Reduces number of insects. Replaces this purpose.
Meat, poultry, fish reducing the number of fresh, refrigerated types of food- and renders	0.1–10	Delays spoilage by microorganisms in the product. Kills some poisoning bacteria

		disease-causing parasites (e.g., trichinae) harmless
Strawberries and other fruits	1-5	Extends shelf life by delaying mold growth.
Grains, fruits, vegetables and other foods subject to insect infestation	0.1–2	Kills insects or prevents them from reproducing. Could partially replace postharvest fumigants used for this purpose.
Bananas, avocados, mangoes, papayas, guavas and certain other noncitrus fruits	1.0 maximum	Delays ripening.
Potatoes, onions, garlic, ginger	0.05–0.15	Inhibits sprouting.
Grains, dehydrated vegetables, other foods	Various doses	Desirable physical changes (e.g., reduced rehydration times).

*kGy (kilogray). For more information on the units used to measure radiation, see Appendix I, page 00.

In addition to extending shelf life, some applications of irradiation eliminate hazards in foods or change the physical properties of foods in desirable ways. The major applications of irradiation are summarized below; they are discussed in detail by M. C. Lagunas-Solar in a 1995 article in the *Journal of Food Protection.*[1]

*Radiation Pasteurization**

Processes that decrease the number of microorganisms in a food product without completely sterilizing it are called pasteurization. Such processes have many uses; the heat pasteurization of milk is just one example. It destroys any pathogenic (disease-producing) microorganisms that might be present in the milk and delays spoilage by significantly reducing the number of spoilage microorganisms. Heat pasteurization has little effect on the milk's taste and nutritive value, and the milk is not sterilized by the process. (The shelf-stable fluid milk that is popular in Europe and was recently introduced in the United States is not an irradiated product. This milk, which can be stored safely at room temperature until opening, is sterilized by an ultra–high-temperature heat treatment.)

Irradiation at doses lower than those used in sterilization can be used to pasteurize food products. It can delay the spoilage of highly perishable fresh fish and shellfish, reduce the number of microorganisms in spices, destroy or greatly reduce the number of disease-causing bacteria and parasites in meats and poultry and extend the shelf life of fruits such as strawberries and mangoes. The irradiation of fruits at pasteurization doses has little or no effect on flavor.

Pasteurization by irradiation can be very useful for ensuring the safety of fresh meat and poultry.[2] These foods are frequently contaminated with illness-causing microorganisms such as *Salmonella* and *Campylobacter* that can be killed by radiation pasteurization. Use of the procedure also can remove the potentially lethal hazard of *E. coli* O*157:*H*7* from hamburger meat.

Cooking also kills these pathogenic microorganisms, so properly cooked meat and poultry products are not hazardous even if they have not been irradiated. Microorganisms from mishandled meat and poultry cause many cases of food poisoning each year, however. Contaminated meat or poultry eaten undercooked or raw can cause food-poisoning illnesses. Furthermore, the microorganisms on the contaminated meat or poultry can be transferred, via utensils or dripping, to other foods or to surfaces that will come into contact with hands, mouths or foods.

Disease-causing bacteria are estimated to be responsible for two thirds of the 120 or so foodborne disease outbreaks that occur annually in the United States.[3] Improved food-handling practices could reduce the number of illnesses from this source; but radiation pasteurization gives us an additional, complementary tool with which to deal with the problem.

Radiation Sterilization[*]

Irradiation is used currently to sterilize more than 50 percent of the sterile disposable medical devices (including gauze, surgical gloves and supplies) used in the United States. The same technique can also be applied to foods, and extensive research has been conducted on the subject.[4] A relatively high-dose irradiation treatment can kill all the microorganisms that might otherwise grow in a food. The sterilized food can then be stored in sealed containers for long periods at room temperature without being spoiled by microorganisms. This process is analogous to canning, which uses heat treatment to achieve the same preservation status.

The United States Army has sponsored extensive research on radiation sterilization, with the goal of producing higher quality meals for troops in the field. Some of the Army's earliest experimental radiation-sterilized foods, produced in the 1950s and early 60s, did not rate highly in terms of flavor, aroma or texture. Improvements have been made in the irradiation procedure, however; and the radiation-sterilized meat and poultry products produced by current methods have been rated by both military personnel and food experts as being as good as or even superior to their canned counterparts in texture, appearance and—in some cases—flavor and vitamin retention.

Meat, poultry, some types of fish and shellfish, some vegetables and entire meals are suitable for radiation sterilization. Other foods, such as dairy products, develop undesirable flavor changes, making them unlikely candidates for commercial irradiation at the present time. Radiation sterilization has been used to sterilize food for NASA's astronauts and for some patients with impaired immune systems. At present, radiation sterilization is not planned for significant commercial production of foods.

Disinfestation

Low-dose irradiation can kill insects in grains and other stored foods. Disinfestation by irradiation can substitute for some of the former uses of the now-banned fumigant ethylene dibromide (EDB). The possibility of such a replacement is one of the major reasons for renewed interest in irradiation in the United States, as the chemical fumigants being used currently in place of EDB have serious disadvantages, including increased hazards for the workers who must apply them.

Irradiation shows promise as an alternative to these postharvest fumigants. With irradiation there would be fewer pesticide residues in treated foods. The irradiation process cannot be regarded as a cure-all, however, or as an immediate solution to the difficulties created by the ban on EDB. Irradiation cannot be used extensively, at least at first, because the necessary facilities do not exist. There are plans to build a "food only" irradiation facility in Washington state, however; and plans for more such facilities can be expected to be announced soon after the U.S. government approves irradiation as a quarantine treatment. Further, for some crops additional research is needed to determine the optimum doses and conditions for radiation disinfestation.

Irradiation would facilitate both interstate and international shipment of fruits and vegetables. Out of fear that a pest problem will be introduced, many states and countries prohibit the importation of foods suspected to be contaminated with live insects or their eggs. During the 1981 Mediterranean fruit fly (Medfly) infestation in California and Florida, the reluctance of buyers in other states and countries to accept produce that might be contaminated with live Medflies led to substantial economic losses. In the 1990s, a loss of revenue from diminishing sugar cane and pineapple production has increased Hawaii's need to export exotic fruits, but buyers' concerns about infestation have limited the state's ability to do so. Irradiation would allow growers to ship their produce to uninfested areas without risk of spreading an insect infestation.

For consumers, irradiation disinfestation would mean improved fruit quality. Traditional treatment of fruit fly infestations, for example, includes extensive cold treatment or hot water–immersion processing of the infested fruit before shipment. Both methods can affect the quality of the treated fruit. Irradiation would also mean fewer chemical residues on food.

One drawback of irradiation as an insect-control process is that irradiation, like heat treatment, does not leave any active agent in an unpackaged food to protect it against reinfestation. It can be expected, however, that packaging will be required whenever irradiation is used as a quarantine treatment.

It is possible—and there has been much enthusiasm about the prospect—that killing insects with irradiation might increase the amount of food available in developing countries. A substantial proportion of the food produced in these countries is destroyed by insects before it reaches consumers. Irradiation alone cannot do the job, but irradiation combined with effective methods of storage, chemical additives and / or packaging to prevent reinfestation could accomplish it.[5,6]

Sprout Inhibition

Very-low-dose irradiation treatment inhibits the sprouting of vegetables such as potatoes, onions and garlic. Irradiation can replace the chemicals currently used for this purpose. The United States and many other nations have approved this treatment for white potatoes and garlic. The treatment is used commercially in Japan and elsewhere.

Delay of Ripening

Low-dose irradiation delays ripening and therefore extends the shelf life of some fruits, including strawberries, bananas, mangoes, papayas, guavas, cherries, tomatoes and avocados.

Eliminating Trichinella Hazard in Pork

A low dose of radiation similar to that used to inhibit vegetable sprouting or delay fruit ripening can eliminate the potential hazard of trichinosis from fresh pork[7-9] without significantly affecting the flavor or texture of the meat. Irradiated pork cannot cause trichinosis even if it is undercooked or eaten raw. The irradiation treatment works by impairing the development of

Trichinella spiralis, the parasite that causes trichinosis, so that it cannot mature, go through its life cycle and cause disease in humans.

The United States is one of the few technologically developed countries that still has a problem with trichinosis transmitted by commercial pork. Although the disease is uncommon, it can be serious and several cases occur in the United States each year. Some of the cases involve recent immigrants who have come to the United States from areas where trichinosis is not a problem and so are unaware of the need to cook American pork thoroughly.

Currently, many countries will not accept pork exported from the United States unless the meat is heat treated or frozen (freezing can kill the *Trichinella* parasite). Irradiation could play a major role in the U.S. pork industry's effort to develop a certified *Trichinella*-free pork supply, and it would make U.S. pork more acceptable in international commerce.

Physical Improvements

Irradiation can produce desirable physical changes in some foods. Bread made from irradiated wheat has greater loaf volume when certain dough formulations are used, and irradiated dehydrated vegetables reconstitute more quickly than nonirradiated vegetables.

How Can One Treatment Do So Many Different Things?

Irradiation causes a variety of changes in living cells. High-dose irradiation damages or kills cells and thus can kill microorganisms or insects. Lower doses alter biochemical reactions such as those involved in fruit ripening. Low doses also interfere with cell division, thus preventing irradiated vegetables from sprouting and preventing irradiated parasites and insects from reproducing.

EFFECTS OF IRRADIATION

Is Irradiation the Same Thing as Cooking in a Microwave Oven?

No. Irradiation involves the treatment of food with ionizing radiation. The process produces ions, free radicals and excited molecules in the food that cause the desired effects. By contrast, in a microwave oven foods are exposed to microwaves, a type of nonionizing radiation that generates heat by increasing the molecular motion of the water molecules in moist foods.

Does Irradiation Make Food Radioactive?

No. The types of radiation approved for the treatment of foods do not induce radioactivity in the food.

Does Irradiation Generate Radioactive Wastes?

No. The process simply involves exposing food to a source of radiation. It does not create any new radioactive material. When radioactive isotopes of cobalt or cesium are used as the radiation source, they must be disposed of properly after they are no longer usable for the treatment of food. But using these materials for food irradiation does not make their eventual disposal more difficult. Indeed, "spent" cobalt can be reconstituted and reused, reducing the very small amounts of waste even further.

SAFETY OF FOOD IRRADIATION

Are Irradiated Foods Safe to Eat?

Yes. The safety of food irradiation has been systematically and comprehensively evaluated. The Joint Expert Committee on the Wholesomeness of Irradiated Food (JECFI) of the Food and Agriculture Organization (FAO), the International Atomic Energy Agency (IAEA) and the World Health Organization (WHO) concluded that "Irradiation of any food commodity up to an overall average dose of 10 kGy* introduces no toxicological hazard; hence, toxicological testing of food so treated is no longer required."[10] The JECFI also stated that irradiation of food up to a dose of 10 kGy introduces no special microbiological or nutritional problems. It is important to note that most food irradiation typically uses doses lower than 10 kGy (see Table 1, page XX).

Investigations since 1981 have continued to support the IECFI's confidence in the safety of food irradiation.[11] These investigations included a human feeding trial in China in which 21 male and 22 female volunteers consumed 62 to 71 percent of their total caloric intake as irradiated foods for 15 weeks.[12]

How Has the Safety of Irradiated Foods Been Tested?

Assessing the safety of irradiated foods has involved investigations in the following areas:

- Radiation Chemistry
- General Toxicology / Animal Testing

- Nutrition
- Microbiology
- Packaging

Radiation Chemistry

Scientists have collected substantial information on the chemical changes that occur when foods are irradiated. Many of the substances produced by irradiation (radiolytic products) have been identified through the use of sensitive analytical techniques. “Radiolytic” does not mean radioactive. It simply means that these substances are produced by irradiation. Most of these radiolytic products have proved to be familiar substances that exist in nonirradiated foods or that are also produced in foods by conventional processes such as cooking. In 40 years of searching, using highly sensitive techniques, no substances truly unique to the irradiation process have been identified. The safety of radiolytic products has been examined very critically, and no evidence of a hazard has been found.[13]

The same radiolytic products are formed in foods regardless of the radiation dose; only the amounts of the radiolytic products differ. Therefore, the results of an investigation carried out on the radiolytic products formed in a food irradiated at a high dose can generally be applied to lower dose treatments of the same food. Also, chemically similar foods have been shown to react to irradiation in similar ways; the same kinds of radiolytic products are formed. It thus is not necessary to study every irradiated food in detail; information obtained about the safety of radiolytic products in one food can be applied to the evaluation of other, chemically similar foods. This approach to safety evaluation has been dubbed “chemiclearance.”

General Toxicology/Animal Testing

The most common procedure for evaluating the safety of foods or food ingredients is to feed them to animals and observe the animals’ growth, reproduction and general health. Many such studies have been conducted, in which irradiated foods were fed to a number of animal species. Some studies involved observations of several generations of animals.

Animal tests provide a good indication of the safety of a food or food substance and are an effective way to detect general toxicological hazards. Properly designed laboratory animal tests can also detect cancer hazards and reproductive problems. Most animal studies are quite conservative. The animal feeding studies carried out with irradiated food have consistently failed to find evidence of a health hazard.

One of the most notable of these animal studies was a six-year feeding study involving high-dose irradiated chicken. The study was conducted for the U. S. Army and the U.S. Department of Agriculture (USDA). In this study, which has been described as the most extensive study of a food product or process in history, more than 600,000 pounds of irradiated chicken were fed to several generations of test mice, hamsters, rats, rabbits and dogs.

The evaluation of the massive amounts of data produced by the study was completed in 1985. It was concluded that there was no evidence that radiation-sterilized chicken would pose any toxicological hazard to humans.[14] A similar study in The Netherlands showed no evidence of any toxicological hazard for humans who ate irradiation-sterilized ham**.**

Nutritional Studies

The nutritional value of foods must be protected. Nutritional studies have shown that low-dose irradiation treatments do not cause significant decreases in the nutritional quality of foods. High-dose treatments (sterilization) cause measurable losses of some vitamins, but these losses are generally similar to those caused by other processing techniques, such as canning, that produce a similar degree of preservation. Such losses therefore are not considered a drawback to the use of radiation for food preservation.[15]

Microbiological Studies

It has been determined under a variety of circumstances that irradiation inactivates microorganisms and parasites. Microbiological studies have shown that radiation sterilization can destroy microorganisms, including botulism bacteria, with the same or greater degree of efficacy as the heat treatment used to destroy these organisms in commercially canned foods.

There has been some concern that the risk of food poisoning might be increased by radiation doses in the pasteurization range. If such an irradiation treatment prevented spoilage that a consumer would otherwise have been able to see or smell but allowed food-poisoning organisms to grow, an unwary consumer theoretically could be poisoned. The consumer might eat an unsafe food because he or she was not warned by the off-odors or discoloration usually produced by spoilage microorganisms.

This concern is not unique to irradiation; it also applies to other processes, including heat pasteurization and chemical treatments, that cause the partial destruction of microorganisms in a food. And spoilage, even in foods that have received no processing, cannot always be relied upon as an indicator that foods are unsafe. Food that looks and smells acceptable may harbor pathogenic bacteria or their toxins. Nevertheless, the possibility that irradiation might cause a hazard of this type has been investigated. The results of these studies indicate that under properly controlled conditions of processing, packaging, handling and distribution, irradiation would not increase the risk of food poisoning.[16-20]

Packaging Materials

Because some foods will already be packaged at the time of irradiation, the effects of irradiation on food packaging materials has been studied. The irradiation treatment must not impair the packages' integrity, or the packaged food could be subject to later contamination.

Many packaging materials that might be used for irradiated foods have been tested for safety. It has been found that most materials can be used; glass is an exception because irradiation affects its color. The FDA has approved a variety of packaging materials for use in irradiation. Packaging materials for many foods may also be irradiated without food in them to sterilize them before filling.

Would a Food Irradiation Facility Endanger the Community in Which It Is Located?

No. A food irradiation plant would not endanger a community. It would be no different from the approximately 40 medical-products irradiation plants and the more than 1,000 hospital radiation-therapy units now operating in the United States. None of these facilities has been found to endanger the surrounding community. To be sure, a food irradiation facility must be designed, constructed and operated properly, but that does not represent a new challenge; the necessary precautions are well understood because they have long been applied in the design, construction and maintenance of other types of irradiation facilities.

Could There Be a "Meltdown"?

No. It is impossible for a "meltdown" to occur in a food irradiation plant. An irradiator is not a nuclear reactor. It is simply a processing plant containing a shielded area within which foods are exposed to a source of ionizing radiation. The radiation sources used in food irradiation cannot overheat, explode, leak or in any other way be released.

Would People in the Area Be Exposed to Dangerous Radiation When Radioactive Materials Were Transported to and from the Facility?

No. Like all potentially hazardous substances, radioactive materials must be transported carefully, with appropriate safety precautions. In the United States the Nuclear Regulatory Commission (NRC) has jurisdiction over the safe storage and disposal of radioactive material as well as over the operation of facilities. The Department of Transportation (DOT) has carrier requirements for the transport of hazardous materials, including radioactive cobalt and cesium.

These substances have been transported to irradiation facilities and hospitals throughout the world for many years without difficulty. The containers used for the transport of radioactive cobalt are so well shielded and damage resistant that the DOT permits them to be shipped by common carrier.

There is no transport problem at all if an irradiation facility uses machine-generated radiation, because no radioactive isotopes are involved in such an operation.

Would Workers in a Food Irradiation Plant Be Exposed to Hazardous Radiation?

No. As a result of long experience in designing and operating similar types of irradiation facilities, the necessary precautions for worker safety in a food irradiation plant are well understood. These precautions are enforced in the United States by federal governmental agencies.

The Occupational Safety and Health Administration (OSHA) is responsible for regulating worker protection from all sources of ionizing radiation. Food irradiation plants that use cobalt or cesium as their radiation source must be licensed by the Nuclear Regulatory Commission or an appropriate state agency. The NRC is responsible for the safety of workers in NRC-licensed facilities.

Plants in the United States that use machine-generated radiation are under the jurisdiction of the FDA, which establishes appropriate performance standards to ensure worker safety.

Is Food Irradiation Being Promoted Because It Is a Way to Dispose of Radioactive Wastes?

No. Spent fuel from nuclear reactors is not used in irradiation facilities. Of the four possible radiation sources for use in food irradiation, only one—cesium—is a by-product of nuclear fission. This radiation source might therefore be called a waste product, but it is rarely described as such. The term “waste” is usually reserved for substances of no value, and radioactive cesium is both very expensive and in short supply. The supply of radioactive cobalt, the most commonly used nuclear source, is also limited. It is not a "waste" product and so must be manufactured. Cobalt 60 suppliers can recycle spent material, making it a renewable resource for food irradiation.

LEGAL AND REGULATORY ASPECTS OF FOOD IRRADIATION

How Have International Health Organizations Reacted to Food Irradiation?

Generally, international health organizations have been very enthusiastic about the use of irradiation to preserve food. After evaluation of the scientific data, they are confident of irradiation's safety. A 1981 World Health Organization (WHO) document stated:

> Radiation chemistry studies have now shown that the radiolytic products of major food components are identical. . . . Most of these radiolytic products have also been identified in foods subjected to other, accepted types of food processing. . . . The nature and concentration of these radiolytic products indicate that there is no evidence of toxicological hazard.
>
> The technological and economic feasibility of food irradiation on an industrial scale should be established. A wider variety of foods should also be studied with respect to their suitability for processing by irradiation.[10]

WHO reaffirmed its support of irradiated foods in 1994 after another extensive review of all existing data.[11] The international organization concerned with food standards—the Codex Alimentarius Commission of the United Nations Food and Agricultural Organization (FAO) and WHO—has endorsed these WHO conclusions.

How Have United States Health and Scientific Organizations Reacted to Food Irradiation?

Organizations such as the American Medical Association (AMA) and the Institute of Food Technologists (IFT) have long been on record on behalf of the safety of food irradiation. The IFT's Expert Panel on Food Safety and Nutrition has published an analysis of the subject ("Radiation Preservation of Foods") and an update ("Perspective on Food Irradiation"). Both publications are listed in the "Suggestions for Further Reading" at the end of this report. In 1993 the AMA's Council on Scientific Affairs called food irradiation a "safe and effective process that increases the safety of food when applied according to government regulations."[21] Both the Council for Agricultural Science and Technology[3] and the American Dietetics Association[22] support the use of food irradiation.

What Is the Legal Status of Food Irradiation Around the World?

Forty countries have approved some applications of irradiation, and irradiated foods are now marketed in 27 countries. In Japan 15,000 to 20,000 tons of potatoes are irradiated each year to prevent spoilage due to sprouting. A wide variety of irradiated foods has been approved in The Netherlands, and plants there are irradiating about 8,000 tons of food annually. About 8,000 to 10,000 tons of food are irradiated each year in Belgium.

The estimated total quantity of irradiated food that entered commercial channels in 1990 was 500,000 tons. Worldwide, about 20,000 tons of irradiated spices and dry vegetable seasonings were used in 1992. Table 2 gives a partial list of irradiated products approved by various countries as of 1995.

TABLE 2: Foods Approved for Irradiation* **

Country	**Food Product**	**Country**	**Food Product**
Argentina	garlic, onions, potatoes, strawberries	Israel	fresh fruits and vegetables, nuts, onions, potatoes, poultry, 36 spices,
Bangladesh	condiments, fish and fish products, onions, potatoes, spices, rice, wheat	Italy	garlic, onions, potatoes
Belgium	garlic, gum arabic, onions, paprika, pepper, potatoes, shallots, strawberries, spices	Japan	potatoes
Brazil	fish and fish products, fruits, maize, potatoes, poultry, rice, spices, wheat	Korea	dried mushrooms, dried vegetables, onions, potatoes, powdered fish and shellfish, spices, sterile meals
Bulgaria	potatoes, onions, garlic, grains, dry food concentrates, dried fruits, fresh fruits	Mexico	chicken products, cereals, fish and fish products, fruits, garlic, onions, potatoes, rice and rice products, vegetables, wheat and wheat products
Canada	certain dried vegetables, cod and haddock fillets, onions, potatoes, poultry, spices, wheat flour	The Netherlands	asparagus, cocoa beans, strawberries, mushrooms, hospital meals, potatoes, shrimp, onions, poultry, soup greens, fish fillets

Country	**Food Products**	**Country**	**Food Products**
Chile	chicken, fish products, onions, papaya, potatoes, rice, spices, wheat	Norway	spices
China	apples, cereal grains, cooked meat products, dried fruits, garlic potatoes, rice, spices	Pakistan	garlic, onions, potatoes, spices
Costa Rica	chicken, legumes, fruits, fish and fish products, onions, potatoes, rice, wheat	Poland	garlic, onions, spices
Croatia	cereal grains, egg products, fish, dried fruits, meat, onions, potatoes, poultry spices	Philippines	potatoes, onions, garlic
Cuba	cocoa beans, onions, potatoes, seafood, spices	Russian Federation	dry food concentrates, fresh and dried fruits, grains, onions, potatoes, poultry
Czech Republic	potatoes, onions, mushrooms	South Africa	potatoes, onions, garlic, avocados, beans, chicken, papaya, mangoes, strawberries, dried bananas
Denmark	herbs, spices	Spain	potatoes, onions
Finland	spices, herbs, hospital meals	Syria	chicken, fish and fish products, onions, potatoes, rice, spices, wheat and wheat products

Country	Food Products	Country	Food Products
France	cereals, dried fruits and vegetables, egg products, garlic, onions, potatoes, poultry, shallots, spices,	Thailand	potatoes, onions, garlic, dates, wheat, rice, fish, chicken, fermented sausage
Germany	hospital meals, onions	Ukraine	grains and grain products, meat and meat products, onions, potatoes, spices
Hungary	potatoes, onions, strawberries, spices, mushrooms, grapes, cherries and pears	United Kingdom	cereals, fish, fruit, hospital meals, poultry, spices
India	onions, potatoes, spices	United States	fresh fruits and vegetables, herbs, pork, potatoes, poultry, spices,
Indonesia	beans, garlic, onions, potatoes, rice, spices	Yugoslavia	cereals, dried fruits and vegetables, egg powder, garlic, onion, potatoes, poultry, spices

What Is the Legal Status of Food Irradiation in the United States?

Food irradiation is regulated by the FDA under the terms of the 1958 Food Additive Amendment to the Food, Drug and Cosmetic Act. This law prohibits the use of a new food additive until its sponsor has established its safety and until the FDA has issued a regulation specifying conditions of safe use. The law specifically includes “any source of radiation” in its definition of “food additive.”[23]

Congress apparently grouped irradiation with food additives in order to ensure that irradiation would have to meet the same high standards of safety that new food additives must meet. This legal definition created some problems in early studies of the safety of irradiation. Improvements in safety-testing technology and in the scientific knowledge of radiation chemistry were needed before the safety of irradiated foods could be evaluated adequately.

Although food irradiation was first approved for very limited uses in 1963, its use was not quickly extended to other products, in part because of the difficulties referred to above. It wasn’t until the late 1970s that the FDA began to resolve the regulatory uncertainties that had delayed wider approval of food irradiation in the United States. In 1979 the agency established a committee to review, evaluate and recommend criteria for the safety evaluation of irradiated food. In 1980 the committee recommended a specific policy for determining whether an application of irradiation had been proved safe.[24]

Between 1981 and 1986 the FDA translated the committee's recommendation into formal policy. After considering public comments on its plans, the FDA published a proposed rule for low-dose food irradiation in the *Federal Register*.[25,26]The FDA published its final rule in the 1986 *Federal Register*.[27] That final rule did the following:

- It permitted the irradiation of fruits and vegetables with doses of up to one kGy to "inhibit growth and maturation" (i.e., to prevent sprouting and delay ripening).
- It permitted irradiation of any food at doses up to one kGy for the purpose of insect control.
- It permitted irradiation of foods at doses up to one kGy for other purposes if it could be shown that the irradiation treatment would accomplish its intended purpose.
- It required irradiation to be declared on retail food labels, with the exception of labels on processed foods containing small quantities of irradiated ingredients.

Even after the final rule was issued, some irradiation treatments at doses below 1 kGy, such as *trichina*-control treatments for pork, underwent further regulatory scrutiny before being approved.

Irradiation has now been approved for use in the United States to control insects in wheat and flour (1963); to control insects and microorganisms in spices, herbs and plant-derived dehydrated foods (1983); to control *Trichinella* in pork (1985); to prevent postharvest sprouting by stored potatoes and to control insects and maturation in fruits and vegetables (1986); and to destroy *Salmonella* in poultry (1992).

The FDA is currently evaluating a 1994 petition for irradiating beef, veal and other red meats.[28] If approval is granted, the FDA will set a maximum approved treatment dosage for such products. About six months after FDA approval, the USDA's Food Safety and Inspection Service (FSIS) will prepare its own regulation, setting minimum effective treatment dosages and establishing operating instructions for irradiation facilities.

Now That Irradiation Is Gaining Government Approval, Will Its Use Be Expanded?

Most experts predict that irradiation will be used more widely, but the extent of its use will depend on many factors. Those factors include regulatory actions, consumers' and retailers' attitudes toward irradiation and other processes used for the same purposes, the economics of irradiation and competing processes, and the nature of labeling requirements.

Some people have claimed that there must be little interest in irradiation in the United States because no one in this country has taken advantage of the FDA's approval of irradiation for sprout inhibition in white potatoes or for the insect disinfestation of wheat products. But in these instances good, inexpensive alternatives to irradiation treatment already are available, so there is little economic incentive to irradiate.

Most irradiation applications are alternatives to other food-processing steps—to treatment with a chemical, for example. Irradiation will have to compete with these other techniques in the marketplace. If irradiated foods are more expensive than foods processed in other ways, and if there is no improvement in quality or safety to justify the irradiated foods' extra cost, they are not likely to be successful. It is possible, however, that decreased losses due to spoilage will offset price increases brought about by the use of an additional technology.

There are some instances in which irradiation has no competition. No other treatment currently exists that can guarantee that fresh raw pork is safe from *trichina.* (*Trichina* can be killed by heating or freezing, but these processes yield cooked pork and frozen pork, not fresh raw meat.) Similarly, while some chemical-wash treatments to kill surface microorganisms exist, no practical alternative besides irradiation could destroy harmful microorganisms that have penetrated deep into poultry and red meat products.

In other cases, irradiation may be clearly superior to the available alternatives. For example, now that the fumigant EDB has been replaced by less satisfactory fumigants and physical treatments, irradiation may be the best insect disinfestation method for some commodities, such as spices and fruits.[29]

What About Product Labeling?

Since 1966 the FDA has required that irradiated whole foods be labeled as such. In 1986 a mandatory green "Radura"* logo was added to this labeling requirement. Labeling requirements could hamper the commercialization of some applications of irradiation even if consumers are willing to buy foods labeled "irradiated." In many cases irradiation will be competing with techniques that do not need to be declared on the label—heat processing, freezing and the use of fumigants, for example. Thus, the food processor who chooses to irradiate faces additional record-keeping and labeling requirements that competitors who choose other treatments do not have.

There is no health-related reason why irradiated foods must be labeled. There is no known population subgroup that needs to avoid these foods, and people do not have to know that a food is irradiated to know how to handle it safely. On the other hand, comments submitted to the FDA suggest that many people want to know when foods have been irradiated. This desire to know is a strong argument in favor of labeling for informational—not warning—purposes.

FDA officials have stated that the purpose of any label that might be adopted is to be informative, but there are concerns that irradiation labels could be misinterpreted.

If irradiation is indicated on a label while other treatments are not, consumers might incorrectly assume that the unlabeled foods are unprocessed. An individual who rejects labeled, irradiated onions in favor of an unlabeled alternative might make a different choice if the alternative package were to carry the label “treated with [full chemical name] to prevent sprouting.”

In some countries, including The Netherlands and South Africa, irradiated foods are identified only by the Radura symbol on the label. In South Africa, the use of the symbol is required at the wholesale level but is voluntary on retail food packages. At first, few retailers wanted to use the symbol; but as the process has gained consumer acceptance, more retailers have used it as a form of promotion.

With increased consumer education, the irradiation label may become a positive selling point. A Chicago–area supermarket has been selling irradiated produce and irradiated raw chicken successfully for about two years. The store made information on the irradiation process and its usefulness in rendering poultry *Salmonella* -free available to its clientele for about a year prior to the irradiated poultry’s introduction. The produce packages carry the irradiation symbol and the statement “irradiated for freshness and quality.” The poultry label says “to control *Salmonella* and other food-borne bacteria.”

CONCLUSIONS

Irradiation could bring many benefits to consumers in the United States. Its introduction will increase the variety of techniques that can be used to provide a safe, wholesome and convenient food supply. Other benefits include decreased spoilage of fresh fruits and vegetables and the killing of harmful organisms such as *Salmonella* in chicken and parasites (such as *trichina*) in pork.

Extensive scientific testing has shown that the proper use of food irradiation does not present a health hazard. All the evidence indicates that U.S. consumers have nothing to fear from irradiated foods; rather, we can look forward to a greater variety of high-quality, long-lasting—and in certain cases, safer—food products when this process comes into more widespread use.

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Appendix I. Some Terms Frequently Used in Discussions of Food Irradiation*

High-energy electrons: Streams or beams of electrons accelerated by a machine to energies of up to 10 million electron volts (MeV). Electrons are also emitted by some radioactive materials; in this case they are called “beta rays.”

Gamma Rays: Electromagnetic radiation of very short wavelength, similar to high-energy X rays. Gamma rays are emitted by radioactive isotopes of cobalt and cesium as these isotopes spontaneously disintegrate.

Kilogray (kGy); Gray (Gy): A gray (Gy) is the unit (or level) of energy absorbed by a food during irradiation. 1000 Gy = 1 Kilogray (kGy).

Radiation Pasteurization: Treatment of food with doses of radiation large enough to kill or render harmless all *disease-causing* organisms except viruses and spore-forming bacteria. Processed foods usually must be stored under refrigeration.

Radiation Sterilization: Treatment of food with doses of radiation large enough to kill or render harmless all disease-causing and spoilage organisms. The resulting processed food can be stored at room temperature in the same way as thermally sterilized (canned) foods.

Radura: A symbol or logo developed in The Netherlands and recognized internationally by the World Health Organization and the International Consulting Group on Food Irradiation as the official symbol that indicates a product has been subjected to irradiation.

X rays: Ionizing electromagnetic radiation of a wide variety of short wavelengths. They are usually produced by a machine in which a beam of fast electrons in a high vacuum bombards a metallic target.

**Adapted from* Radiation Preservation of Foods, *Institute of Food Technologists, Chicago, 1983.*

Appendix II: Food Irradiation: Some Major Milestones

1895: Wilhelm Konrad von Roentgen, German physicist, discovers X rays.

1896: Antoine Henri Becquerel, French physicist, discovers emission of radiation from naturally occurring radioactive materials. Minsch publishes proposal to use ionizing radiation to preserve food by destroying spoilage microorganisms.

1904: Prescott publishes studies at Massachusetts Institute of Technology (MIT) on the bactericidal effects of ionizing radiation.

1905: U.S. and British patents issued for the use of ionizing radiation to kill bacteria in foods.

1905–1920: Significant basic research is conducted on the physical, chemical and biological effects of ionizing radiation.

1921: USDA researcher Schwartz publishes studies on the lethal effect of X rays on *Trichinella spiralis* in raw pork.

1923: First published results of animal feeding studies to evaluate the wholesomeness of irradiated foods.

1930: French patent issued for the use of ionizing radiation to preserve foods.

1943: MIT group, under U.S. Army contract, demonstrates the feasibility of preserving ground beef by X rays.

Late 1940s and early 1950s: Beginning of era of food irradiation development by U.S. Government, Atomic Energy Commission, industry, universities and private institutions, including long-term animal feeding studies by the U.S. Army and by Swift and Company (a U.S. meat processing company).

1950: Beginning of food irradiation program by Great Britain and numerous other countries.

1958: The Food, Drug and Cosmetic Act is amended, directing that food irradiation be evaluated as a food additive, not as a physical process. All new food additives, including irradiation, must be approved by FDA before they can be used. The U.S. Congress passes legislation to this effect, which President Eisenhower signs in 1958. This legislation is still the law of the land.

1980: Joint Expert Committee on Irradiation, a joint body of the Food and Agriculture Organization (FAO) of the World Health Organization and the International Atomic Energy Agency, declares that the irradiation of any food commodity up to an overall average dose of 10 kGy “presents no toxicological hazard.”

1983: Codex Alimentarius Commission of the FAO, representing 130 countries, adopts worldwide standards for the application of irradiation to foods.

1995: Irradiation being commercially applied in the United States to preserve poultry, strawberries, tomatoes, mushrooms, onions and citrus products, and to kill insects and parasites in herbs and spices.

Appendix III: Food Irradiation: Regulatory Highlights

1958–59: U.S.S.R. approves irradiation preservation of potatoes and grains.

1960: Canada approves irradiation preservation of potatoes.

1963-64: U.S. FDA approves irradiation of bacon, wheat, wheat flour and potatoes.

1964–67: U.S. FDA approves flexible packaging materials for food contact during irradiation processing.

1976: Joint FAO / IAEA / WHO Expert Committee on (safety / wholesomeness of) Food Irradiation (JECFI) approves several irradiated foods and recommends that food irradiation be classified as a physical process.

1979: U.S. FDA Bureau of Foods (Center for Food Safety and Applied Nutrition) forms internal Irradiated Foods Committee.

1980: Joint FAO / IAEA / WHO Expert Committee on (safety / wholesomeness of) Food Irradiation (JECFI) approves all irradiated foods treated with a maximum average dose of 10 kGy.

1983: U.S. FDA and Canadian Health & Welfare Department approve irradiation to kill insects and parasites in spices.

1985: U.S. FDA approves irradiation of pork to control trichinosis.

1986: U.S. FDA approves irradiation of fruits and vegetables and other foods up to doses of one kGy to delay maturation and / or to treat insect infestation.

1990: U.S. FDA approves irradiation of poultry up to doses of 3 kGy for control of pathogens.

1994: U.S. FDA receives petition for irradiation of beef, veal and other red meats to control disease-causing microorganisms.

* This and other technical terms frequently encountered in discussions of food irradiation are defined in Appendix 1 on page XX

* Marcotte M. *Commercial Irradiation of Food and Agricultural Commodities* Nordion International, Inc.June, 1994:Summary tables.

** International Atomic Energy Agency. *Supplement to Food Irradiation Newsletter,* 19, No. 2. October 1995:2–34.