FMI Backgrounder

Food Irradiation

Executive Summary

Food irradiation uses radiant energy – electron beams, gamma rays or x-rays — to rid food of harmful microorganisms, insects, fungi and other pests, and to retard spoilage. The process can inhibit sprout growth on potatoes and onions. It does not make food radioactive. Irradiation kills pathogens and makes them incapable of reproduction.

Irradiation was patented for food preservation by a French scientist in 1905. American research began in the 1920s. Since then, hundreds of scientific studies worldwide have found that irradiation is an effective food safety tool and poses no significant risks to human health or the environment.

The research has shown that irradiation destroys microorganisms that cause foodborne illness, such as *Salmonella*, *E. coli* O157:H7, *Campylobacter jejuni* and *Listeria monocytogenes*; reduces post-harvest losses due to insects and spoilage; and extends the shelf life of foods. Proponents say the technology could reduce the need for some hazardous pesticides, fumigants and preservatives. Food irradiation improves the safety of foods for the people most highly susceptible to such illnesses, including diabetics, transplant patients, people on cancer therapies, HIV/AIDS patients, and the very young and elderly.

Opponents argue that research has not proved the safety of irradiation. They say that irradiation produces potentially hazardous by-products such as benzene, formaldehyde, cyclobutanones and possibly other compounds that have not been identified. They cite research showing that irradiation reduces the levels of some vitamins. Opponents also say that the transportation and use of radioactive materials pose an unnecessary risk to the public and workers. This concern does not apply to irradiation by electron beams or x-rays.

A 1958 amendment to the Food, Drug and Cosmetic Act requires that irradiation be regulated as a food additive, directing the Food and Drug Administration (FDA) to verify the safety of all applications before commercial use. The Office of Management and Budget (OMB) has the final word, as it does with all regulatory actions.

More than 50 countries have approved the use of irradiation for about 50 food products, and 33 are using the technology commercially, according to the International Atomic Energy Agency (for a detailed table on commercial use, visit www.iaea.org/icgfi/documents/commeact.htm). The U.S. government has approved irradiation for use on meat, poultry, pork, fresh fruits and vegetables, grains and other foods, as well as dry spices and seasonings.

Food irradiation uses radiant energy — electron beams, gamma rays or x-rays — to rid food of harmful microorganisms, insects, fungi and other pests, and to retard spoilage.

Food irradiation improves the safety of foods for immune-compromised people, including diabetics, transplant patients, people on cancer therapies, HIV/AIDS patients and the very young and elderly.

FOOD MARKETING INSTITUTE
655 15th Street, N.W., Washington, DC 20005
202.452.8444 fax: 202.429.4519
fmi@fmi.org ■ http://www.fmi.org

1. What is food irradiation?

A process in which gamma rays, X-rays or electrons are used to disinfect, preserve or sterilize food. The technology kills pathogens or renders them unable to reproduce.

2. How is food irradiated?

There are several methods. Food packed in crates or boxes is placed on conveyor belts and moved into the heart of the irradiator, where it is exposed to the radiation source. Electron beam irradiators can cleanse packaged food at the end of food-processing production lines.

Irradiation disrupts the molecular structure; kills or reduces the number of bacteria and yeasts; delays the formation of mold; and sterilizes or kills parasites, insects, eggs and larvae.

High-energy waves pass through the food, exciting the electrons in both the food and any pests or pathogens. When the electrons absorb enough energy, they break away from their atoms, leaving positively charged centers behind. Irradiation disrupts the molecular structure; kills or reduces the number of bacteria and yeasts; delays the formation of mold; and sterilizes or kills parasites, insects, eggs and larvae.

Levels of absorbed radiation are currently measured in kilograys (kGy).[1] The scientific community has defined three levels of food irradiation:

- Low dose, up to 1 kGy — kills insects on fruit and grain and kills or prevents the maturation of *Trichinella*, the parasite that causes trichinosis in pork.
- Medium dose, 1–10 kGy — kills most of the bacteria that cause foodborne illness and spoilage. Doses of 1.5–3.0 kGy are used for poultry.
- High dose, 10+ kGy — can sterilize meat and other foods and decontaminate herbs and spices.

Gamma irradiation creates enough energy to penetrate products in shipping containers. Electron beam irradiation, unable to penetrate as much, is applied to packaged food, such as pre-made hamburger patties. To penetrate larger items, electron beams can be directed at a sheet of metal, causing x-rays to be emitted from the other side.

3. Is food irradiation new?

The process was patented for food preservation in 1905 by a French scientist. American research began in 1921 when the U.S. Department of Agriculture (USDA) reported that irradiation would effectively kill trichinae in pork. Since then, it has gradually gathered momentum with improvements in the technology and the need for new methods to combat foodborne illness.

Irradiation at high doses is currently used to sterilize more than half of all medical supplies, along with cotton swabs, contact lenses, saline solution, tampons, teething rings and cosmetics.

Irradiation at high doses is currently used to sterilize more than half of all medical supplies, along with cotton swabs, contact lenses, saline solution, tampons, teething rings and cosmetics.

[1] Some people may be more familiar with the older measure kilorad. The word "rad" stands for "radiation absorbed dose." One kilogray equals 100 kilorads.

4. Why the current interest in food irradiation?

The process offers a promising means to control microorganisms that cause disease. (See the FMI Backgrounder Foodborne Illnesses.) Bacteria and other pathogens cause millions of foodborne illnesses each year, according to medical research, with thousands of cases resulting in death. Food irradiation could help prevent many of the deaths and illnesses associated with *E. coli* O157:H7, since these bacteria are easily killed when irradiated at small to medium doses. Especially susceptible to foodborne illness are the young and old and victims of serious diseases.

Food irradiation could help prevent many of the deaths and illnesses associated with E. coli O157:H7, since these bacteria are easily killed when irradiated at small to medium doses.

Concerns about food security after the events of September 11 have also increased consumer interest, along with the use of electron beam irradiation to kill anthrax in U.S. mail.

5. What are the benefits of food irradiation?

Proponents cite the following benefits:

- It destroys most bacteria, molds, parasites and other organisms that cause foodborne disease. Irradiation at doses up to 3.0 kGy eliminates over 99 percent of the *Salmonella* organisms on or in poultry, according to USDA tests. In ground beef, irradiation at doses up to 0.8 kGy eliminated over 90 percent of five common pathogens (*E. coli* O157:H7, *Campylobacter jejuni*, *Listeria monocytogenes*, *Salmonella* and *Staphylococcus aureus*) in 1993 tests by the Center for Food Safety and Quality Enhancement at the University of Georgia. The center determined that doses up to 3.0 kGy would effectively destroy all these microorganisms in ground beef. Food scientists also believe that low-dose irradiation would eliminate harmful organisms in oysters, raw fish (sashimi) and other seafood. Irradiation does not kill the bacteria that cause botulism, nor will it kill viruses at the dose levels used for foods.
- By killing pests on domestic and imported produce, irradiation eliminates the need for post-harvest fumigants that can leave undesirable residues. It also reduces the need for pesticides when crops are cultivated.
- Irradiation decreases post-harvest food losses, according to the International Atomic Energy Agency (IAEA). Many countries lose large amounts of grain because of insect infestation, molds and premature germination — all of which irradiation can eliminate or control. For these reasons, Belgium, France, Netherlands and Russia irradiate grains, potatoes, onions and other products on an industrial scale.
- The process can extend the shelf life of food by inactivating spoilage organisms and, in some produce, by delaying ripening and sprouting. Irradiated strawberries, for example, last at least a week longer in the refrigerator than untreated ones.

Many countries lose large amounts of grain because of insect infestation, molds and premature germination — all of which irradiation can eliminate or control.

In addition, irradiation offers some advantages over traditional preservation methods. In most cases, foods irradiated in air-tight packages retain more of their original texture, flavor and nutrient value than foods that

are thermally sterilized and canned

6. Is irradiated food safe to eat?

In the 2000 report *Food Irradiation: Available Research Indicates that Benefits Outweigh Risks*, the General Accounting Office (GAO) concluded: "The cumulative evidence from over four decades of research — carried out in laboratories in the United States, Europe and other countries worldwide — indicates that irradiated food is safe to eat. The food is not radioactive; there is no evidence of toxic substances resulting from irradiation; and there is no evidence or reason to expect that irradiation produces more virulent pathogens among those that survive irradiation treatment."

***"The cumulative evidence from over four decades of research — carried out in laboratories in the United States, Europe and other countries worldwide — indicates that irradiated food is safe to eat. — General Accounting Office,* Food Irradiation: Available Research Indicates That Benefits Outweigh Risks, 2000**

The report noted that numerous prominent health and scientific organizations worldwide agree that food irradiation is safe, including:

U.S. Government Agencies

Centers for Disease Control and Prevention
Food and Drug Administration
Department of Agriculture
Public Health Service

U.S. Scientific and Health-Related Organizations

American Dietetic Association
American Medical Association
American Veterinary Medical Association
Council for Agriculture Science and Technology
Institute of Food Technologists
National Association of State Departments of Agriculture

International Scientific and Health-Related Organizations

Codex Alimentarius Commission
Food and Agriculture Organization
International Atomic Energy Agency
Scientific Committee of the European Union
World Health Organization

To review the GAO report, visit the Web site www.gao.gov/, select "GAO Reports," then "Find GAO Reports" and enter the report number RCED-00-217, or call the agency at 202-512-1530.

7. What are the safety concerns cited by opponents?

Many are concerned that widespread use of irradiation could prompt producers, distributors and consumers to be less aggressive in practicing other sanitation measures. Some believe that the research on safety issues is inadequate and inconclusive. The major safety issues:

Opponents are concerned that widespread use of irradiation could prompt producers, distributors and consumers to be less aggressive in practicing other sanitation measures.

- *Radiolytic Products* — Some gamma rays in irradiation break chemical bonds to form short-lived, unstable molecules called free radicals. These combine with each other and with other food molecules to create "radiolytic products." Irradiating meat can produce benzene, for example, and irradiating carbohydrate-rich foods can yield formaldehyde. This effect is not limited to irradiation: cooking, canning and pasteurization also produce radiolytic products. At the

prescribed dosage levels, irradiation produces small amounts of such compounds. Among the radiolytic products may be "unique" compounds that may cause adverse health effects.

- *Destruction of the "Smell Test"* — Irradiation may reduce bacteria that provide consumers with an odor indicator of spoilage. Food scientists believe that irradiation at the low doses prescribed will not eliminate all odor-causing spoilage bacteria, preserving the smell test. This effect may depend on the dose, temperature, packaging and product. Consequently, FDA is investigating this issue on a case-by-case basis.
- *Declines in Fecundity (number of offspring)* — Research has yielded mixed results. One study showed a significant reduction in the offspring of fruit flies (*Drosophila* melanogaster) fed gamma-irradiated chicken. Tests on beagles showed a higher rate of healthy offspring among the pregnant females fed irradiated chicken. In another test, only mice fed cooked chicken showed a decrease in offspring. FDA has concluded that none of these studies demonstrated an irradiation-related effect.
- *Aflatoxin* — Certain molds produce these naturally occurring carcinogens, especially in grain. One study suggested that aflatoxins grow better on irradiated grain because the treatment destroyed competing microorganisms. Aflatoxin growth will not occur, researchers say, when grain is treated with a dose high enough to kill all microorganisms on grain that is subsequently kept isolated from further contamination. Most foods can be prepackaged before being irradiated, reducing the risk of recontamination.
- Opponents and supporters agree that irradiation should not be a substitute for safe sanitation practices. Irradiated foods can be re-contaminated if they contact with unclean surfaces or raw foods, or if they are otherwise improperly stored, handled or prepared. In particular, ground beef must still be cooked to an internal temperature of 160°F (71°C) — verified with a thermometer — to ensure that the pathogens have been killed.

Opponents and supporters agree that irradiation should not be a substitute for safe sanitation practices. Irradiated foods can be re-contaminated if they come into contact with unclean surfaces or raw foods. In particular, ground beef must still be cooked to an internal temperature of 160°F (71°C).

8. Does irradiation change the nutritional quality of food?

Irradiation does not affect protein, carbohydrate or mineral content. As with canning, pasteurization and cooking, it can reduce the levels of certain vitamins, including E, C, A and K and thiamin. Recent research has indicated that the effects on vitamin levels at the permitted doses are quite small.

FDA notes that the extent of vitamin reduction depends on the dose, food, temperature and other factors that are usually controlled to minimize the impact on vitamin content, taste, texture and other food properties.

Vitamin losses "wouldn't mean too much for someone who ate an occasional irradiated food," according to the Center for Science in the Public Interest ("Food Irradiation: Zapping Our Troubles Away," *Nutrition*

Irradiation does not affect protein, carbohydrate or mineral content. As with canning, pasteurization and cooking, it can reduce the levels of vitamins, including E, C, A and K and thiamin.

Action Health Letter, p. 6). "But people whose diets were based largely on irradiated foods could be in trouble."

9. Will transportation and use of radioactive sources endanger workers and the public?

Because some forms of irradiation involves hazardous materials, stringent regulations have been adopted for the transportation of the radioactive materials required. The use and transportation of radioactive materials is closely monitored by the Nuclear Regulatory Commission (NRC), the Department of Transportation and state agencies.

The radioisotopes — sealed in double-encapsulated metal rods — must be shipped in reinforced metal casks designed to withstand the most severe accidents, including collisions, punctures and exposure to fire and water.

The risk to workers is minimized by protection measures required at irradiation plants. The facilities housing the irradiator are usually surrounded by six-foot-thick concrete walls. The radioactive source itself is stored in a pool of water and is raised only during the irradiation process and only after all doors are closed. Failure to comply with safety regulations can lead to temporary plant closure by the NRC. One plant had its license revoked twice in 1986 because of repeated violations involving worker safety precautions. Radiation Technology Chairman Martin Welt was forced to resign after ordering that a lock system to protect workers be bypassed.

Four decades of experience with about 40 U.S. irradiators has produced a relatively clean safety record.

Four decades of experience with about 40 U.S. irradiators has produced a relatively clean safety record. Two incidents in the 1970s exposed two workers to nonlethal doses of irradiation. In 1988, a leaking capsule at a Georgia irradiator contaminated the pool of holding water, prompting the facility to switch isotopes — from cesium-137 to the safer cobalt-60. Since cobalt-60 does not produce neutrons, neither a nuclear chain reaction nor meltdown can occur. Not a single accident has occurred in more than 1 million isotope shipments.

Food irradiation creates little nuclear waste, although some of the equipment used adds to the waste. All U.S. plants that irradiate food with gamma rays use cobalt-60 that is supplied by MDS Nordion, based in Kanata, Ontario. The rods must be replaced every 15–20 years and are returned to the Canadian supplier for storage or recycling.

Since electricity is the source of power, electron beam processing does not involve the use of potentially dangerous chemicals or gases. No radioactive isotopes are used in the process.

Electron beam systems do not use radioactive isotopes or other potentially hazardous substances since electricity is the power source. When not in use, they are turned off.

10. Do other countries irradiate food?

More than 50 countries have approved irradiation for about 50 products according to the International Atomic Energy Agency (IAEA), and 33 are irradiating foods and spices commercially. The chart below provides a partial listing based on data furnished by WHO, FAO and IAEA.

	Avocados	Cereals	Cocoa Beans	Fish	Garlic	Herbs	Mangoes	Mushrooms	Onions	Papaya	Pork	Potatoes	Poultry	Red meat	Rice	Spices	Strawberries	Wheat
Argentina					■			■	■			■				■	■	
Bangladesh				■	■		■		■	■		■			■	■		■
Belgium						■			■			■				■	■	
Brazil	■			■			■		■	■		■	■		■	■	■	■
Canada						■			■				■			■		■
Chile			■	■			■		■	■			■		■	■	■	■
China		■			■			■	■		■		■					
Cuba	■		■		■				■							■		
Denmark		■														■		
Finland																■		
France					■	■			■							■	■	
Hungary		■						■	■				■			■	■	
India									■				■			■		
Indonesia		■			■				■				■			■		
Israel		■	■					■								■	■	
Italy					■	■			■				■			■		
Japan																		
Mexico		■			■	■	■	■	■	■	■		■		■			■
Netherlands		■				■												
Pakistan		■				■										■		
Russia									■						■			
South Africa	■			■			■		■							■		
South Korea		■			■			■	■				■			■		
Spain									■									
Syria			■	■			■		■	■					■	■	■	■
Thailand			■	■	■		■		■	■			■		■	■	■	■
United Kingdom					■		■						■					
United States	■	■			■	■	■	■	■	■	■	■	■	■	■	■	■	■

Chile, for example, irradiates about 130 metric tons (mt) per year, mostly spices, according to Nordion. Russia treats 400,000 mt each year, mostly to eliminate insect infestations from imported grain coming into its port of Odessa. China irradiates garlic to prevent sprouting, and Japan treats potatoes for the same reason. France irradiates poultry to control contamination.

11. To what extent is irradiated food available in the United States?

American astronauts have been eating irradiated food since 1972, when the Apollo 17 crew selected ham as the first irradiated flight meal. Irradiated ham, beefsteak, turkey and corned beef were served on 19 of the first 24 shuttle flights. The meats were radiation-sterilized at high doses. The U.S. military consumes irradiated meals when in the field. Individuals suffering from immune system disorders have also been fed irradiated foods to help reduce the risk of infection from harmful bacteria.

American astronauts have been eating irradiated food since 1972, when the Apollo 17 crew selected ham as the first irradiated flight meal.

Until recently, however, few irradiated foods have been available to the general public. In 2000, Huisken Meats, a subsidiary of Sara Lee Co., began selling irradiated frozen ground beef patties. Titan Corporation's SureBeam® subsidiary irradiates frozen, packaged hamburgers with electron beams and ships them to Huisken for sale. It also sells irradiated beef jerky snacks. Today, Huisken supplies the product to 2,500 retail stores, according to the company.

In 2001, SureBeam® contracted to irradiate products for Cargill Foods, Tyson Foods, Iowa Beef Packers (IBP), /Omaha Steaks, Schwan's and other companies. These companies are now selling irradiated foods — primarily beef patties (frozen and fresh), poultry and pork — to U.S. retailers, including national and regional chains and independent operators. Food retailers are also selling irradiated produce.

Meatpackers are now selling irradiated foods — primarily beef patties (frozen and fresh), poultry and pork — to U.S. retailers, including national and regional chains and independent operators.

In 2002, food irradiation pioneer Food Technology Service launched the I-Care Foods brand, featuring irradiated chicken, turkey, beef and egg products. The company is marketing the brand to people most susceptible to life-threatening diseases and others whose immune systems are weakened by age, cancer therapies and HIV.

Restaurants are now serving irradiated products as well, including Dairy Queen, which is test-marketing irradiated hamburgers in 43 Minnesota stores. If these tests prove successful, the company could eventually make the product available in many or all of its 4,900 U.S. stores.

These developments — coupled with the irradiation of U.S. mail to kill anthrax — have increased public awareness of and interest in irradiated foods.

12. Which foods have been approved for irradiation?

The U.S. government has approved irradiation of the following foods:

- Refrigerated or frozen uncooked red meat, including ground beef (1999) — to eliminate foodborne pathogens, such as *E. Coli* O157:H7 and *Salmonella*, and to extend shelf life.
- Poultry feed (1995) — to eliminate *Salmonella*.
- Fresh or frozen packaged poultry (1990, 1992) — to control *Salmonella*, *Camplylobacter* and other illness-causing bacteria.
- Fresh fruits, vegetables and grains (1986) — to control insects and inhibit growth, ripening and sprouting.
- Pork (1986) — to control the parasite Trichinella spiralis, which causes trichinosis.

- Herbs, spices and vegetable seasonings (1983-1986) — to kill insects and control microorganisms.
- Dry or dehydrated enzyme preparations (1985) — to control insects and microorganisms.
- White potatoes (1964) — to inhibit sprout development.
- Wheat and wheat flour (1963) — to control insects.

13. How is food irradiation regulated?

Under the Food, Drug and Cosmetic Act, food radiation is considered a food additive; consequently, the safety of all new uses must be verified by FDA before they may be employed. Some organizations, including the American Medical Association, have recommended that Congress delete the reference to radiation from the "food additive" definition so that new uses might come to market more quickly, although the change would also result in less government oversight with respect to food safety aspects

Under the Food, Drug and Cosmetic Act, food radiation is considered a food additive; consequently, the safety of all new uses must be verified by FDA before they may be employed.

As with all regulatory actions, final approval for any new application must come from the Office of Management and Budget (OMB), which analyzes the impact of the regulations on consumers and industry.

14. Must irradiated food be labeled?

Labeling has been mandatory since 1966; the radura logo below was mandated in 1986.

The statements "Treated With Radiation" or "Treated by Irradiation" must be prominently placed on packages at the retail and wholesale levels. The labels may also include why the food was irradiated, such as "Irradiated to destroy harmful microbes" or "Irradiated to control spoilage," and the type of irradiation used. For poultry and red meat, USDA's Food Safety and Inspection Service (FSIS) has approved the such statements on labels as "Treated with irradiation for food safety," Treated with irradiation to reduce the potential for foodborne illness," "Treated with irradiation to reduce pathogens such as *E. coli* and *Salmonella*."

Farm Labeling at the wholesale level must also include the warning not to irradiate the product again.

For unpackaged fruits and vegetables, the retailer must either:

- Label each individual item.
- Place a sign next to the commodity displaying the required logo and label to the customer.
- Use the labeling of the bulk container to inform customers that the foods have been irradiated.

The labeling requirements apply to foods that have been irradiated in their entirety (first generation). In addition, USDA now requires labeling to indicate the inclusion of an irradiated meat or poultry ingredient in any multi-ingredient meat or poultry food product.

15. Is there any way to determine if an item has been irradiated and, if so, at what dose level?

Companies use dosimeters to verify that products have been subjected to the prescribed amount of irradiation. When irradiating pallets, these measuring devises are placed on products throughout including cases inside. When irradiating products, dosimeters are placed on the packages.

There is no accurate method to determine whether and at what dose the food itself has been irradiated, largely because the low doses used in most applications cause few detectable changes in a food's chemistry. Work is ongoing to develop such detection methods.

There is no single accurate method to determine whether and at what dose the food itself has been irradiated, largely because the low doses used in most applications cause few detectable changes in a food's chemistry.

FDA requires processors to retain irradiation records one year longer than the shelf life of the irradiated food or for three years, whichever period is shorter. Both the irradiation plant and the records must be available for inspection by FDA to ensure that the processor is complying with federal regulations.

16. Does irradiated food cost more?

To date, most irradiated foods cost only a few cents more than their untreated counterparts. As the market matures, the cost difference is likely to vary from food to food. By adding another step to food processing, irradiation increases production costs. In some foods, however, these costs may be offset by reduced spoilage, longer shelf life and strong consumer demand.

17. How do consumers feel about food irradiation?

In the 2001 *Shopping for Health* survey of more than 1,200 shoppers by FMI and *Prevention* magazine, 57 percent said they are "somewhat" or "very likely" to buy irradiated foods, up from 50 percent in the 1996 survey. In addition, the number who said they would not buy such foods at all declined to 9 percent, from 16 percent in 1996.

The 2002 edition of FMI's survey of more that 2,000 consumers (*Trends in the United States: Consumer Attitudes and the Supermarket)* showed a pronounced increase in just two years. In 2002, 53 percent said they are likely to buy a "food product like strawberries, poultry, pork or beef if it had been irradiated to kill germs and keep it safe," compared with 38 percent in 2000.

In 2002, 53 percent said they are likely to buy a "food product like strawberries, poultry, pork or beef if it had been irradiated to kill germs and keep it safe," — compared with 38 percent in 2000.

Guide to Abbreviations

EPA	U.S. Environmental Protection Agency
FAO	Food and Agriculture Organization of the United Nations
FDA	U.S. Food and Drug Administration
FSIS	Food Safety and Inspection Service
IAEA	International Atomic Energy Agency
kGy	kilogray
krad	kilorad
NBS	National Bureau of Standards
NRC	Nuclear Regulatory Commission
OMB	Office of Management and Budget
USDA	U.S. Department of Agriculture
WHO	World Health Organization

Sources of Additional Information

Center for Food Safety & Applied Nutrition
Food and Drug Administration
5100 Paint Branch Parkway
College Park, MD 20740
301-436-2170 ■ www.cfsan.fda.gov/
Press Office: 301-436-2335

Food Safety and Inspection Service
U.S. Department of Agriculture
Room 1175-South Building
1400 Independence Avenue, S.W.
Washington, DC 20250
202-720-7943
Meat and Poultry Hotline
1-800-535-4555; 202-720-3333 ■ www.fsis.usda.gov/

International Atomic Energy Agency
P.O. Box 100
Wagramer Strasse 5
A-1400, Vienna, Austria
43-1-20600 ■ www.iaea.org

World Health Organization
CH-1221 Geneva 27
Switzerland
41-22-791-2111 ■ www.who.org