MF- 2426 Food Safety

Food Irradiation

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Food irradiation is one means of enhancing the safety of food. Food irradiation can be applied to treat numerous problems in the food supply: insect infestation of cereal grains, sprouting of potatoes, rapid ripening of fruits and vegetables, and bacterial growth in meat. This food preservation method is not widely used in the United States food industry. Recent outbreaks of foodborne illnesses, however, have provided impetus for wider acceptance of this technology.

Radiation is a form of energy. We receive natural radiation from the sun and other natural components of the environment. Like other forms of radiant energy, the radiant energy waves used to irradiate food make up part of the electromagnetic spectrum.(Figure 1, see page 2) Gamma rays and x-rays are short wave radiations: ultraviolet rays from the sun and radio waves are long wave radiations. In the 1890s, radioactive substances and x-rays were discovered. Intense research on the biological effects of these radiations began immediately, and beneficial uses were soon found. The greatest use of radiation has been in the medical field—medical and dental x-rays, detection and treatment of diseases, sterilization of medical equipment, medical devices, pharmaceutical products, and in the production of sterilized food for special hospital diets.

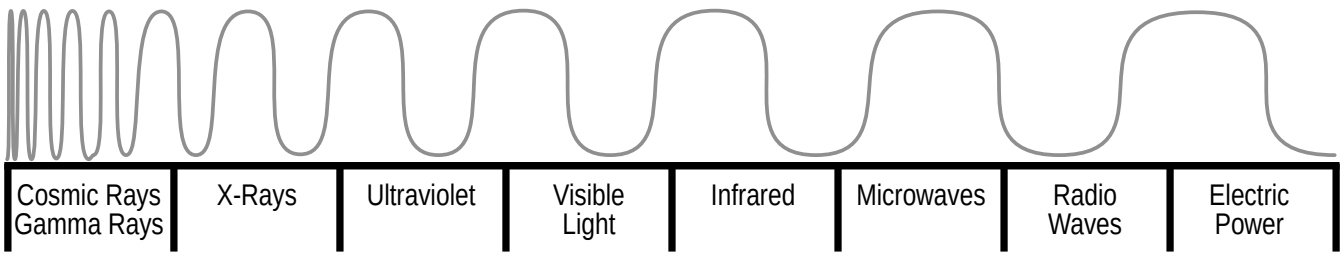
History of Food Irradiation

Food irradiation, a processing technology, has been proven to be a wholesome process through many years of scientific study. Early in the 1920s, a French scientist discovered that irradiation could be used to preserve food, but the technology was not studied extensively in the United States until after World War II. Food irradiation research resulted from the "Atoms for Peace" program established by President Eisenhower in the early 1950s. Based on numerous studies performed by the office of the Surgeon General of the U.S. Army, food irradiated with doses up to 56 kGy were determined to be safe for human consumption. In the early 1970s, the National Aeronautics and Space Administration adopted the process to sterilize meat for astronauts to consume in space.

The first Food and Drug Administration approval to use irradiation on a food product came in 1963 to irradiate wheat and wheat flour for insect disinfestation. (Table 1, see page 2) In 1983, approval was granted to kill insects and control microorganisms in a specific list of herbs, spices and vegetable seasoning. Irradiation was approved for the treatment of pork to prevent trichinosis in 1985. That same year, approval was given to control insects and microorganisms in dry enzyme preparations used in fermentation-type processes. In 1986, approval was granted to control insects and inhibit rapid ripening in such foods as fruits, vegetables, and grains. Irradiation was approved for packaged fresh or frozen uncooked poultry for the control of bacteria in May 1990.

The FDA, in December 1997, approved irradiation of fresh or frozen red meats such as beef and lamb in the United States. That approval was for the purpose of controlling microorganisms, such as *E. coli* O157:H7 and other foodborne pathogens.

Figure 1: *Electromagnetic spectrum*



Source: Satin, Morton. (1993) Food Irradiation, A Guidebook. Technomic Publishing Company, Inc. Lancaster, PA.

Table 1: *Food approved for irradiation*

Product	Dose Permitted (kGy)	Date	Purpose
Wheat, Wheat Flour	0.2-0.5	1963	Insect Disinfestation
White Potatoes	0.05-0.15	1964	Sprout Inhibition
Pork	0.3-1	1985	*Trichinella spiralis* control
Dried Enzymes	10 (max.)	1986	Microbial control
Fruit	1 max.	1986	Delay ripening, insect disinfestation
Vegetables	1 max.	1986	Disinfestation
Herbs & Spices	30.max	1986	Microbial control
Vegetable seasonings	30 max.	1986	Microbial control
Poultry	3 max.	1990	Microbial control
Frozen , packaged meat for use in space program	44 min.	1995	Sterilization
Animal feed & pet food	2-25	1995	*Salmonella* control
Meat, uncooked, chilled	4.5 max.	1997	Microbial control
Meat, uncooked, frozen	7.0	1997	Microbial control

Source: Olson, D.G. Food Technology, 52(1), 1998.

The approval was based on the FDA's scientific review of numerous research studies conducted worldwide on the effects of irradiation on a variety of meat products. The studies investigated the chemical effects of radiation, impacts on nutrient content of irradiated products, toxicity concerns, and the effects on microorganisms in or on irradiated products. The established maximum dose for refrigerated meat, meat by-products, and certain meat food is 4.5 kGy; the maximum permitted dose for frozen meat, frozen meat by-products, and certain frozen meat food products is 7.0 kGy. The USDA gave its approval to irradiate fresh and frozen meat products in December 1999.

Many other countries have already adopted this process to pasteurize or preserve food. Worldwide, over 30 countries have approved some form of irradiation, and consumers readily accept irradiated products. The Netherlands irradiate approximately 2 tons of food daily and Belgium irradiates 1 ton daily. South Africa routinely irradiates mangoes, papayas, and vegetables. Canada has a facility dedicated to irradiating potatoes. At least one irradiated muscle food (meat, poultry, or seafood) is cleared for use in 18 countries such as Chile, France, and the Netherlands.

What is Food Irradiation?

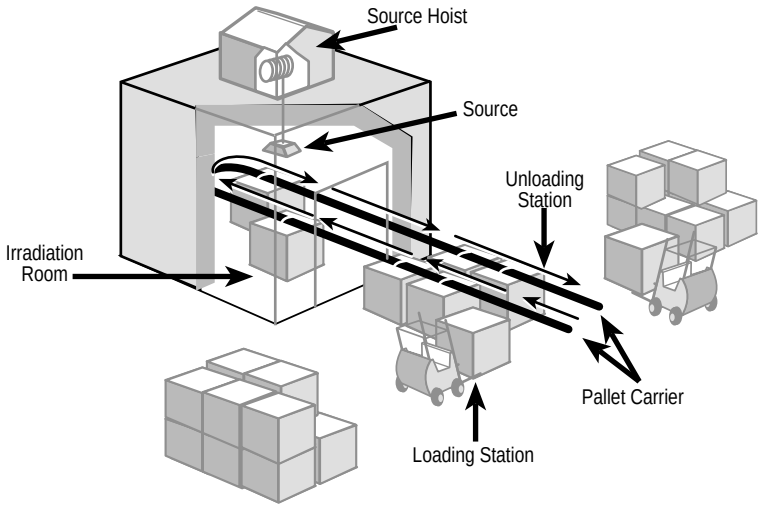
Irradiation is the process of applying high energy to a material, such as food, to pasteurize, sterilize, or extend its shelf-life by killing microorganisms and insects. Sources of ionizing radiation that have been used include gamma rays, electron beams and x-rays. Gamma rays are produced by radioactive isotopes such as Cobalt-60 or Cesium-137: Cobalt-60 is the most common radioisotope source used in gamma ray radiation. Electron beams are generated by a linear accelerator, which is powered by electricity. Electron beams and x-rays are sometimes referred to as"machine" sources of irradiation.

In food irradiation, the"dose" that a food receives is not something added to the food. The dose is the amount of radiation absorbed by the food during the exposure time. The dose is controlled by the intensity of the radiation and the length of time the food is exposed to the source. Irradiation is measured by the unit known as the "gray"(Gy), which refers to the absorbed dose and is defined in energy terms as a dose of one joule per kilogram of absorbing material. The FDA's regulations describe radiation levels in the term of a kilogray (kGy) which is equal to 1000 Gy. The FDA has broken down the levels of irradiation into three categories. A "low" dose of irradiation is up to 1 kGy and is designed to control insects in grains, inhibit sprouting in white potatoes, control *Trichinae* in pork, and inhibit decay in fruits and vegetables. A "medium" dose is 1 to 10 kGy and can be used to control pathogens in meat, poultry and fish, and also delay mold growth on strawberries and other fruits. A "high" dosage is greater than 10 kGy and is used to kill microorganisms and insects in spices, and can be used to commercially sterilize foods.

The Food Irradiation Facility

The facilities that are used for food irradiation are very similar to the facilities used to sterilize medical equipment, but in no way resemble a nuclear reactor. (Figure 2) There are no materials that could cause widespread distribution of the radioactive materials. The facilities must comply with plant and worker safety requirements of the Nuclear Regulatory Commission and the Occupational Safety and Health Administration. In the irradiation facility, the radiation source, such as Cobalt-60, is contained in a slender pencil-like stainless steel casing about 18 inches long by 3/8 inch diameter. The casings are contained in a lead lined chamber.

Figure 2: *Schematic of an irradiation facility*



Source: Satin, Morton. (1993) Food Irradiation, A Guidebook. Technomic Publishing Company, Inc. Lancaster, PA.

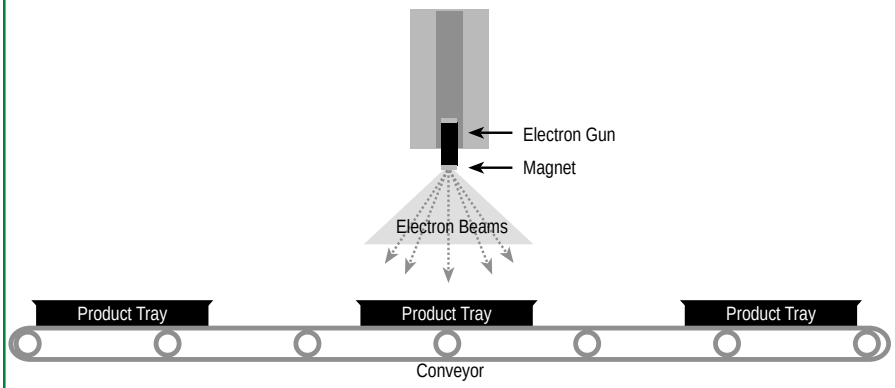
Pallets of packaged food are placed on a conveyor belt and passed between 6-1/2 foot thick concrete walls into and through a chamber where the food is exposed to the radiation source. Pallets may be turned to allow uniform exposure over the route. Exposure to the radiation source is controlled by the speed of the conveyor belt. The United States has one large commercial facility in Florida -- Food Technology Services, Inc., that is dedicated to food irradiation.

Iowa State University has a commercial-size linear accelerator facility used for electron beam food irradiation. A new facility is under construction near Sioux City, Iowa, to irradiate fresh meat products. Accelerators work on the same principle as a television tube. Instead of electrons being widely dispersed and hitting a phosphorescent screen at low energy levels, the electrons are concentrated and accelerated to 99 percent of the speed of light. (Figure 3) As the electron beam penetrates the food product, rapid reactions at the molecular level are produced within the product to reduce viable bacteria that may be present. This type of technology, using electricity, may have more consumer appeal than the use of gamma rays.

Labeling of Irradiated Foods

Irradiated foods that are sold at the retail level are required by the FDA to bear the irradiation symbol, the radura, and the statement "treated with radiation" or "treated by irradiation." The manufacturers are allowed to add a phrase which truthfully describes the purpose of the treatment, such as "treated with radiation to control spoilage." For unpackaged fruits and vegetables, labels could be on each piece of produce, on the shipping container, placed so it can be viewed by the consumer, or on a sign near the display of the produce identifying the use of the treatment. For irradiated foods sold at the wholesale level, the symbol and wording is still required and the statement "do not irradiate again" must also be stated. However, if these foods are incorporated into other foods as ingredients, the resulting products are not required to be labeled.

Figure 3: *Electron beam irradiation*



Source: Satin, Morton. (1993) Food Irradiation, A Guidebook. Technomic Publishing Company, Inc. Lancaster, PA.

Changes in Irradiated Food

Foods that have been irradiated are not radioactive. At the low levels of radiation used in food processing, only chemical changes are possible, not changes that would make the food radioactive. Over 35 years of research suggests that the changes in irradiated food is very similar to the changes that occur when food is conventionally cooked. Studies show that there are no toxic or mutagenic effects from irradiated food and irradiation doesn't leave chemical residues in food.

Food irradiation is a "cold" process, meaning there is only a slight increase in the temperature of the food during this process. There is little, if any, change in the physical appearance of irradiated foods, as they do not undergo the changes in texture or color as foods preserved by heat pasteurization, canning or freezing. Some off-flavors in meat and excess tissue softening in fresh peaches and nectarines have been reported. Research conducted at Kansas State University concluded that ground beef flavor, juiciness, and tenderness were not adversely affected by irradiation. The researchers also concluded that chilled and frozen ground beef patties irradiated at 1.5 and 3.0 kGy did not show any adverse affects on vitamin retention or meat color.

There are some chemical changes in irradiated foods, but these changes are not unlike the chemical changes that occur during conventional cooking methods. When high energy particles impact matter, electrons are lost from atoms and ions form. Newly formed "radiolytic" products may then interact to create new compounds; a few of these reactions may produce an off-flavor. The FDA concluded, "very few of these radiolytic products are unique to irradiated foods; approximately 90% of the radiolytic products are known to be natural components of food." One category of radiolytic products is made up of fatty acids that are similar to the products of the breakdown of triglycerides (fats). Some radiolytic products are similar to the compounds found commonly in the waxy coverings of fruits such as apples, pears, and berries. These radiolytic products have been extensively tested and have shown no evidence of toxicity or hazard to consumers.

Consumer Acceptance

The acceptance of food irradiation has been increasing. A study conducted in 1993 showed that many consumers were ready to accept irradiated produce and irradiated poultry. Four markets, one in Illinois and three in Florida, offered their customers irradiated strawberries and other produce such as onions and tomatoes. During the first three months of 1993, the customers at the Illinois market were buying irradiated strawberries over conventional strawberries 20:1. The irradiated berries had a much longer shelf life than untreated berries which often show signs of mold soon after purchase. A similar trend was seen when irradiated poultry was introduced in all four markets. Consumers realized the benefits of irradiated poultry and were willing to purchase it. A 1998 Food Marketing Institute telephone survey showed that 55 percent of 2,002 respondents would be likely to buy a food product such as strawberries, poultry, pork or beef if it had been irradiated to kill bacteria.

A recent study examined consumer acceptance of irradiated meat. It was found that individuals who consume more beef were less concerned about the irradiation process. People who received factual information on the process were also less concerned. Females, older consumers, and those with lower education and income levels, tended to be more concerned about the effects of irradiation.

Some consumers show a preference of an irradiated product over a non-irradiated product when faced with the purchasing decision. Almost half of the individuals who stated they were not sure if they would buy irradiated meat, did choose the irradiated meat when faced with a buying decision in the market place. In the same study, some individuals who stated they would not buy the irradiated product did buy it when faced with the purchasing decision.

Slowly, consumers are gaining knowledge about the benefits of food irradiation and its potential to reduce the risk of foodborne disease, but this process is not a replacement for proper food handling practices. Irradiation, like other prevention methods, is but one method used to prevent foodborne illness.

Glossary of Terms

Cesium 137: A metal, which can be used in food irradiation, that can give off ionizing energy. This isotope is not likely to be used in U.S. food irradiation processes.

Cobalt 60: A metal, which is most commonly used in food irradiation, that can give off ionizing energy.

Electron beam: Can be produced from machines capable of accelerating electrons. Electrons cannot penetrate very far into the food, compared to gamma rays or x-rays.

Food irradiation: The process of exposing food to radiation or rays of energy.

Gamma rays: Form part of the electromagnetic spectrum, occurring in the short wave length, high energy region of the spectrum.

Gray: Unit that measures the radiation dose (Gy). One gray equals one joule of energy absorbed per kilogram of food being irradiated.

Ionizing radiation: Rays of energy that move in short, fast wave patterns and can penetrate cells.

Radiation dose: The quantity of radiation energy absorbed by the food as it passes through the radiation field during processing.

Radiolytic products (RP's): Chemicals produced in food when the food is irradiated that are very similar to the chemicals produced during conventional cooking.

Radura symbol: A circular symbol that must appear on all irradiated food sold at wholesale and retail.

X-rays: form part of the electromagnetic spectrum, occurring in the short wave length region and are produced by a mechanical source.

Website Sources for Food Irradiation

International Atomic Energy Agency
http://www.iaea.or.at/worldatom/inforesource/other/food

American Council on Science and Health
http://www.acsh.org/publications/booklets/irradiated.html

International Food Information Council
http://www.ificinfo.health.org/ qanda/qairradi.htm

U.S. Department of Agriculture
http://www.fsis.usda.gov

Institute of Food Technologists
http://www.ift.org/sc/
http://www.ift.org/sc/ sc_f07.html

Iowa State University Extension
http://www.exnet.iastate.edu/pages/families/fs/rad/
irradhome.html

K-State Research and Extension Food Safety
http://www.oznet.ksu.edu/foodsafety

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