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Division of Bacterial and Mycotic Diseases

Frequently Asked Questions about Food Irradiation

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What is food irradiation?

Food irradiation is a promising new food safety technology that can eliminate disease-causing germs from foods. Like pasteurization of milk, and pressure cooking of canned foods, treating food with ionizing radiation can kill bacteria and parasites that would otherwise cause foodborne disease. Similar technology is used to sterilize medical devices so they can be used in surgery or implanted without risk of infection. The food that NASA astronauts eat has been sterilized by irradiation to avoid getting foodborne illness in space. The effects of irradiation on the food and on animals and people eating irradiated food have been studied extensively. These studies show clearly that when irradiation is used as approved on foods:

- disease-causing germs are reduced or eliminated
- the food does not become radioactive
- dangerous substances do not appear in the foods
- the nutritional value of the food is essentially unchanged

Irradiation is a safe and effective technology that can prevent many foodborne diseases.

Which foodborne diseases could be prevented with irradiation?

Treating raw meat and poultry with irradiation at the slaughter plant could eliminate bacteria commonly found on raw

meat and raw poultry, such as *E. coli* O157:H7, *Salmonella*, and *Campylobacter*. These organisms currently cause millions of infections and thousands of hospitalizations in the United States every year. Irradiating prepared ready-to-eat meats like hot dogs and deli meats, could eliminate the risk of *Listeria* from such foods. Irradiation could also eliminate parasites like *Cyclospora* and bacteria like *Shigella* and *Salmonella* from fresh produce. The potential benefit is also great for those dry foods that might be stored for long times and transported over great distances, such as spices and grains. Animal feeds are often contaminated with bacteria like *Salmonella*. Irradiation of animal feeds could prevent the spread of *Salmonella* and other pathogens to livestock through feeds.

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What is the actual process of irradiation?

Three different irradiation technologies exist, that use three different kinds of rays: gamma rays, electron beams and x-rays.

The first technology uses the radiation given off by a radioactive substance. This can be either a radioactive form of the element cobalt (Cobalt 60) or of the element cesium (Cesium 137). These substances give off high energy photons, called gamma rays, which can penetrate foods to a depth of several feet. These particular substances do not give off neutrons, which means they do not make anything around them radioactive. This technology has been used routinely for more than thirty years to sterilize medical, dental and household products, and it is also used for radiation treatment of cancer. Radioactive substances emit gamma rays all the time. When not in use, the radioactive "source" is stored down in a pool of water which absorbs the radiation harmlessly and completely. To irradiate food or some other product, the source is pulled up out of the water into a chamber with massive concrete walls that keep any rays from escaping. Medical products or foods to be irradiated are brought into the chamber, and are exposed to the rays for a defined period of time. After it is used, the source is returned to the water tank.

Electron beams, or e-beams, are produced in a different way. The e-beam is a stream of high energy electrons, propelled out of an electron gun. This electron gun apparatus is a larger version of the device in the back of a TV tube that propels electrons into the TV screen at the front of the tube, making it light up. This electron beam generator can be simply switched on or off. No radioactivity is involved. Some shielding is necessary to protect workers from the electron beam, but not the massive concrete walls required to stop gamma rays. The electrons can penetrate food only to a depth of three centimeters, or a little over an inch, so the food to be treated must be no thicker than that to be treated all the way through. Two opposing beams can treat food that is twice as thick. E-beam medical sterilizers have been in use for at least fifteen years.

The newest technology is X-ray irradiation. This is an outgrowth of e-beam technology, and is still being developed. The X-ray machine is a more powerful version of the machines used in many hospitals and dental offices to take X-ray pictures. To produce the X-rays, a beam of electrons is directed at a thin plate of gold or other metal, producing a stream of X-rays coming out the other side. Like cobalt gamma rays, X-rays can pass through thick foods, and require heavy shielding for safety. However, like e-beams, the machine can be switched on and off, and no radioactive substances are involved. Four commercial X-ray irradiation units have been built in the world since 1996.

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How does irradiation affect foods?

The foods are not changed in nutritional value and they are not made dangerous as a result of the irradiation. The high energy ray is absorbed as it passes through food, and gives up its energy. The food is slightly warmed. Some treated foods may taste slightly different, just as pasteurized milk tastes slightly different from unpasteurized milk. If the food still has living cells, (such as seeds, or shellfish, or potatoes) they will be damaged or killed just as microbes are. This

can be a useful effect. For example, it can be used to prolong the shelf life of potatoes by keeping them from sprouting. The energy can induce a few other changes. At levels approved for use on foods, levels of the vitamin thiamine are slightly reduced. This reduction is not enough to result in vitamin deficiency. There are no other significant changes in the amino acid, fatty acid, or vitamin content of food. In fact, the changes induced by irradiation are so minimal that it is not easy to determine whether or not a food has been irradiated.

Irradiated foods need to be stored, handled and cooked in the same way as unirradiated foods. They could still become contaminated with germs during processing after irradiation, if the rules of basic food safety are not followed. Because the irradiated foods have fewer microbes of all sorts, including those that cause spoilage, they may have a longer shelf life before spoiling.

The safety of irradiated foods has been studied by feeding them to animals and to people. These extensive studies include animal feeding studies lasting for several generations in several different species, including mice, rats, and dogs. There is no evidence of adverse health effects in these well-controlled trials. In addition, NASA astronauts eat foods that have been irradiated to the point of sterilization (substantially higher levels of treatment than that approved for general use) when they fly in space. The safety of irradiated foods has been endorsed by the World Health Organization (WHO), the Centers for Disease Control and Prevention (CDC) and by the Assistant Secretary of Health, as well as by the U.S. Department of Agriculture (USDA) and the Food and Drug Administration (FDA).

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How do you measure the amount of irradiation used?

The dose of irradiation is usually measured in a unit called the Gray, abbreviated Gy.. This is a measure of the amount of energy transferred to food, microbe or other substance being irradiated. 10 kiloGrays, or 10,000 Grays, is the same as an older measure, the megaRad. A single chest X-ray has a dose of roughly a half of a milliGray (a thousandth of a Gray). To kill *Salmonella*., fresh chicken can be irradiated at up to 4.5 kiloGrays, which is about 7 million times more irradiation than a single chest X-ray. To measure the amount of irradiation something is exposed to, photographic film is exposed to the irradiation at the same time. The film fogs at a rate that is proportional to the irradiation level.

The killing effect of irradiation on microbes is measured in D-values. One D-value is the amount of irradiation needed to kill 90% of that organism. For example, it takes 0.3 kiloGrays to kill 90% of *E. coli* O157, so the D-value of *E. coli* is 0.3 kGy. These numbers can be added exponentially. It takes two D (or 0.6 kGy in the case of *E. coli*) to kill 99% of the organisms present, 3 D (or 0.9 kGy) to kill 99.9% and so on. Thus, once you know the D-value for an organism, and how many organisms might possibly be present in a food, the technician can estimate how much irradiation it will take to kill all of them. For example, if you think that a thousand *E. coli* O157 could be present in a food, then you want to be able to treat with at least 4 D, or 4 x 0.3 kGy, or 1.2 kGy. The D-values are different for each organism, and need to be measured for each organism. They can even vary by temperature, and by the specific food.

The energy of e-beams and of x-rays is measured in the amount of energy developed by the electron gun, and is measured in electron volts (eV). The usual apparatus runs at 5 to 10 million electron volts (MeV).

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How does irradiation affect disease-causing microbes?

When microbes present in the food are irradiated, the energy from the rays is transferred to the water and other molecules in the microbe. The energy creates transient reactive chemicals that damage the DNA in the microbe, causing defects in the genetic instructions. Unless it can repair this damage, the microbe will die when it grows and tries to duplicate itself. Disease-causing organisms differ in their sensitivity to irradiation, depending on the size of

their DNA, the rate at which they can repair damaged DNA, and other factors. It matters if the food is frozen or fresh, as it takes a higher dose to kill microbes in frozen foods.

The size of the DNA "target" in the organism is a major factor. Parasites and insect pests, which have large amounts of DNA, are rapidly killed by extremely low doses of irradiation, with D-values of 0.1 kiloGray or less. It takes more irradiation to kill bacteria, because they have a somewhat smaller DNA, with D-values in the range of 0.3 to 0.7 kiloGray. Some bacteria can form dense hardy spores, which means they enter a compact and inert hibernation state. It takes more irradiation to kill a bacterial spore, with D-values on the order of 2.8 kiloGray. Viruses are the smallest pathogens with that have nucleic acid, and they are in general resistant to irradiation at doses approved for foods. This means that they may have D-values of 10 kG or higher. The prion particles associated with bovine spongiform encephalopathy (BSE, also known as mad cow disease) do not have nucleic acid at all, and so they are not inactivated by irradiation, except at extremely high doses. This means that irradiation will work very well to eliminate parasites and bacteria from food, but will not work to eliminate viruses or prions from food.

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Which foods can be irradiated?

At low doses, irradiation could be used on a wide variety of foods to eliminate insect pests, as a replacement for fumigation with toxic chemicals that is routine for many foods now. It can also inhibit the growth of molds, inhibit sprouting, and prolong the shelf life.

At higher doses, irradiation could be used on a variety of different foods to eliminate parasites and bacteria that cause foodborne disease. Many foods can be irradiated effectively, including meat, poultry, grains, and many seafoods, fruits and vegetables. It is likely to have greatest application for raw foods of animal origin that are made by mixing materials from many animals together, such as ground meat or sausage.

However, not all foods are suitable for irradiation. For example, oysters and other raw shellfish can be irradiated, but the shelf life and quality decreases markedly because the live oyster inside the shell is also damaged or killed by the irradiation. Shell eggs can sometimes be contaminated on the insides with *Salmonella*. However, irradiation causes the egg whites to become milky and more liquid, which means it looks like an older egg, and may not serve as well in some recipes. Alfalfa seeds used in making alfalfa sprouts can sometimes be contaminated with *Salmonella*.

Using irradiation to eliminate *Salmonella* from the seeds may require a dose of irradiation that also interferes with the viability of the seeds themselves. Combining irradiation with other strategies to reduce contamination with germs may overcome these limitations.

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Which foods have been approved for irradiation in the United States?

A variety of foods have been approved for irradiation in the United States, for several different purposes. For meats, separate approval is required both from the FDA and the USDA.

Approval Year	Food	Dose	Purpose
1963	Wheat flour	0.2-0.5 kGy	Control of mold
1964	White potatoes	0.05-0.15 kGy	Inhibit sprouting
1986	Pork	0.3-1.0 kGy	Kill <i>Trichina</i> parasites

1986	Fruit and vegetables	1.0 kGy	Insect control, increase shelf life
1986	Herbs and spices	30 kGy	Sterilization
1990 - FDA	Poultry	3 kGy	Bacterial pathogen reduction
1992 - USDA	Poultry	1.5-3.0 kGy	Bacterial pathogen reduction
1997 - FDA	Meat	4.5 kGy	Bacterial pathogen reduction
1999 - USDA (pending)	Meat	4.5 kGy	Bacterial pathogen reduction

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Which foods are being irradiated in the U.S.?

A facility in Florida has been irradiating strawberries and other fruits on a limited basis, to prolong shelf life. On a trial basis, fresh tropical fruits from Hawaii have been irradiated before shipping them to the mainland, instead of fumigating them to eliminate the fruit fly pests that could spread to the mainland. Some spices for commercial use have been irradiated. In addition irradiation is widely used to sterilize a variety of medical and household products, from hip joint implants to bandaids and baby pacifiers.

Other technologies used to sterilize fruits, spices and medical devices use toxic chemicals, such as ethylene oxide. Use of irradiation can reduce the use of these other hazardous substances.

How can I tell if the food has been irradiated?

A distinctive logo has been developed for use on food packaging, in order to identify the product as irradiated. This symbol is called the "radura" and is used internationally to mean that the food in the package has been irradiated. A written description may also be present, such as "Irradiated to destroy harmful microbes". It is not required to label a food if a minor ingredient of the food, such as a spice, has been irradiated itself.

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Are consumers ready to buy irradiated foods?

Many consumers are quite willing to buy irradiated foods. This is particularly true if the purpose of the irradiation is clearly indicated. Consumers are interested in a process that eliminates harmful microbes from the food and reduce the risk of foodborne disease. In test marketing of specific irradiated foods, consumers have shown that they are willing to buy them. Typically at least half will buy the irradiated food, if given a choice between irradiated product and the same product non-irradiated. If consumers are first educated about what irradiation is and why it is done, approximately 80% will buy the product in these marketing tests.

Would irradiation replace other foodborne disease prevention efforts?

Irradiation is not a short cut that means food hygiene efforts can be relaxed. Many steps need to be taken from farm to table to make sure that our food supply is clean and safe. Irradiation is a major step forward, but it does not replace other important efforts, including efforts to improve sanitation on the farm and in the food processing plant. For irradiation to be effective, the food that is to be irradiated already needs to be clean. The more initial contamination there is, the higher dose of irradiation it would take to eliminate possible pathogens, and the greater the change in the taste and quality of the food. The protection of irradiation will be overcome if the contamination levels are too high.

The same is true for pasteurized milk. To be pasteurized, milk must be produced in regulated dairy farms, and must be of Grade A quality. Milk that is less than Grade A is not pasteurized for direct sale as milk. Thus, irradiation of food is an important additional step for added safety in the whole farm-to-table continuum of food safety measures.

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Is irradiation of food just like pasteurization of milk?

Irradiation has the potential to be used like milk pasteurization in the future. We have confidence in the safety of pasteurized milk for several reasons. The milk is graded and tested to make sure that the milk is clean enough to pasteurize in the first place. Careful industry standards and regulations monitor the effectiveness of the pasteurization process. The pasteurization occurs just before the milk goes into the carton, so the chance of re-contamination after pasteurization is nearly zero. Similar strategies and designs can make food irradiation as effective as milk pasteurization.

Currently, pasteurization is applied to foods (like milk) that already meet a defined cleanliness standard, and is applied at a dose that gives a standard defined effect. As the irradiation of food becomes commercialized for various foods, similar standardization will be required.

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Who makes sure that the irradiation facilities are operated safely?

The effectiveness of the treatment in eliminating pathogens will be regulated as a food safety process, by either the USDA or the FDA, often in concert with State authorities, just as is the case now for milk pasteurization or retort canning.

The safety of operations of irradiation facilities is regulated separately. This requires extensive worker training, supervision, and regulatory oversight. Facilities using radioactive sources are regulated by the Nuclear Regulatory Commission (NRC). To be licensed, the facility must have been designed with multiple fail-safe measures, and must establish extensive and well documented safety procedures, and worker training. The safe transport of the radioactive sources is regulated by the Department of Transportation.

E-beam and X-ray sources are not monitored by the NRC, but rather by the part of the FDA that regulates medical X-ray devices, and by the same State authorities that regulate other medical, dental and industrial uses of these technologies.

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Have there been any accidents involving irradiation facilities?

Medical sterilization facilities have been operated in this country for more than 30 years, without a fatal accident. Over 100 such facilities are currently licensed, along with at least that many medical radiation treatment centers, and bone marrow transplant centers (which also use Cobalt 60 to irradiate patients). No events have been documented in this country that led to exposure of the population at large to radioactivity. In other countries, a small number of fatal incidents have been documented in which a worker by-passed multiple safety steps to enter the chamber while the source was exposed, resulting in a severe or even lethal radiation injury to themselves.

What radioactive waste is generated?

Is waste storage or transport a problem? Cobalt 60 is manufactured in a commercial nuclear reactor, by exposing non-radioactive cobalt to intense radiation in the reactor core. Cesium 137 is a by-product of the manufacture of weapons-grade radioactive substances. Thus the supply of these two substances, like that of other radioactive materials used in medicine, science and industry, is dependent on the nuclear industry.

The food irradiation facilities themselves do not become radioactive, and do not create radioactive waste. The cobalt sources used in irradiation facilities decay by 50% in five years, and therefore require periodic replacement. The small radioactive cobalt "pencils" are shipped back to the original nuclear reactor, where they can be recharged for further use. The shipment occurs in special hardened steel canisters that have been designed and tested to survive crashes without breaking. Cobalt is a solid metal, and even if somehow something should break, it will not spread through the environment. Cobalt 60 may also be disposed of as a radioactive waste. Given its relatively short half life(5 years) and its stable metallic form, the material is not considered to be a problematic waste.

In contrast to metallic cobalt, cesium is a salt, which means it can dissolve in water. Cesium 137 sources decay by 50% in 31 years, and therefore are not often replaced. When they are replaced, the old cesium sources will be sent to a storage site in the same special transport canisters. If a leak should occur, there is the possibility that the cesium salts could dissolve in water and thus spread into the environment. This happened at a medical sterilizer facility in Decatur, Georgia in 1992, when a steel container holding the cesium cracked, and some cesium leaked into the shielding water tank.

E-beams and X-ray facilities do not involve radioactive substances.

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What about the effect of irradiation on food packaging materials?

The food to be irradiated will often already be in its final package. This raises the question about whether the irradiation has any effect on the packaging that might be transferred to the foods. The effect of irradiation on plastics and other packaging was investigated in the 1960s and early 1970s, in order to identify safe packaging materials for use in the space program. A limited number of materials have been approved for use in packaging food that is to be irradiated. This limited number reflects the limited needs of NASA, not the difficulty of identifying safe products. Many modern packaging materials have simply not been tested. Testing and approving a wider array of packaging materials is critical to the successful commercialization of irradiated foods.

Do other countries irradiate their food?

Many other countries have begun to irradiate food, including France, the Netherlands, Portugal, Israel, Thailand, Russia, China and South Africa.

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What is the CDC's position on food irradiation?

CDC has stated that food irradiation is a promising new application of an established technology. It holds great potential for preventing many important foodborne diseases that are transmitted through meat, poultry, fresh produce and other foods. An overwhelming body of scientific evidence demonstrates that irradiation does not harm the nutritional value of food, nor does it make the food unsafe to eat. Just as for the pasteurization of milk, it will be most effective when irradiation is coupled to careful sanitation programs. Consumer confidence will depend on making food clean first, and then using irradiation or pasteurization to make it safe. Food irradiation is a logical next step to reducing the burden of foodborne disease in the United States.

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How can I find out more about food irradiation?

Basic documents on the safety and efficacy of food irradiation include:

- Lee, Philip R. Assistant Secretary for Health. Irradiation to prevent foodborne illness (Editorial). JAMA 272, p 261, 1994
- Radomyski T, Murano EA, Olson DG, Murano PS. Elimination of pathogens of significance in food by low-dose irradiation: A review. J Food Protection 57:pp73-86, 1994
- Thayer DW, Josephson ES, Brynjolfsson A, Giddings GG. Radiation pasteurization of food Ames (IA). Council for Agricultural Science and Technology; 1996 Issue paper No 7.
- Mussman HC. Potentials of cold pasteurization for the safety of foods of animal origin. J Am Vet Med Assoc, 209, pp 2057-2058, 1996.
- Osterholm, M.T. and M. E. Potter, Irradiation pasteurization of solid foods; taking food safety to the next level. Emerging Infectious Disease, 3:575-577; 1997.
- Joint FAO/IAEA/WHO study group on High-Dose Irradiation. High-dose irradiation: wholesomeness of food irradiated with doses above 10kGy. WHO technical report series 890. World Health Organization, Geneva, 1999.

Several websites with information about food irradiation:

For general information about food irradiation:

- [Foundation for Food Irradiation Education](#)

For a list of countries using irradiation, see <http://www.iaea.org/icgfi>

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