Food Safety

Food Irradiation: Questions & Answers

1. Consumer Benefits

1.1 Why is food irradiated?

Food is irradiated to destroy bacteria, fungi, or insects that cause human disease or cause food to spoil, thereby extending shelf life. Irradiation destroys harmful bacteria such as E. coli O157:H7, salmonella, Listeria, campylobacter and vibrio that are major contributors to the estimated 5000 deaths and 76 million illnesses that occur every year in the United States. When used in this manner, irradiation is comparable to pasteurizing milk, in that the product is left fresh, but is much safer. Irradiation also extends the shelf life of food by retarding maturation in vegetables and reducing spoilage organisms that can grow even under refrigeration. Irradiated strawberries can last a week in the refrigerator without going moldy.

Irradiation can also be used in place of fumigants and other quarantine procedures to allow fruits and vegetables to be imported without risking the introduction of harmful insects.

1.2 Is irradiation used for other products?

Yes. Irradiation is used to sterilize a wide range of heat sensitive medical products including: bandages, blood plasma, burn ointments, catheters, eye ointment, hypodermic syringes, orthopedic implants, IV administration sets, surgical drapes, surgical sponges and swabs, surgeons gloves procedure packs and trays & sutures. It is also used for commercial products including: aerosol saline, baby bottle nipples, baby powder (cornstarch), bulk cotton bales, contact lens cleaning solutions, cosmetic ingredients, bar and liquid soap/detergents/polishes, shampoos hair cream. Food Packaging that may be irradiated to eliminate bacteria includes: bulk food containers, cream cups and lids, dairy/juice cartons, plastic roll stock, heat shrinkable film laminated foil bags.

1.3 Are irradiated foods being sold now?

Irradiation has been approved in 40 countries for some 40-food products. According to the International Consultative Group on Irradiation, each year about a billion pounds of food products and ingredients are irradiated worldwide. In the US, approximately 80 million pounds of spices are irradiated annually. Irradiated chicken is sold at some retail and in restaurants in Florida. Irradiated hamburger patties are currently sold in over 2000 stores in certain parts of the US, and nationally by Schwann's. Increasing amounts of tropical fruits are irradiated and imported from Hawaii including papaya, lychee, mango and carambola (star fruit). Astronauts have eaten irradiated food for years.

1.4 How can I tell if food has been irradiated?

Although you cannot tell by the taste or appearance, federal regulations require that all irradiated foods are labeled and carry a symbol called the radura. Foods that contain irradiated spices or foods served in restaurants do not have to be identified as being irradiated. Sophisticated analytical tests can determine if food has been irradiated (it is interesting to note that organically grown products cannot be identified analytically).

1.5 Will irradiated food cost more?

Any food process will add cost. However food prices would not necessarily rise jut because a product has been treated. Many variables affect food costs, and one of them is the cost of processing. A study conducted by a USDA Economic Research Service economist and a University of Florida professor, found that consumers are willing to pay more a safer food product. Additionally wide scale use of irradiated meat and poultry is expected to drastically reduce the 32 million cases of food borne diseases per year and the $30 billion cost in productivity lost to food-born illnesses in the US each year.

1.6 Are consumers ready to buy irradiated food?

“When consumers are provided with factual information about food irradiation, they will choose irradiated food with confidence,” concluded Dr. Christine Bruhn of the Center for Consumer Science, University of California, Davis found from may different consumer surveys. Also since Schwans switched their ground beef to irradiated, its Vice President Michael Ziebel claims that “sales within Schwan’s ground beef product line have increased more than 20%”.

1.7 Who endorses food irradiation?

Endorsing organizations include: the US Food & Drug Administration, the US Department of Agriculture, US Public Health Service, National Science and Technology Council (Advisors to the Clinton Administration), Council for Agricultural Science and Technology, Center for Disease Control, American Medical Association, American Council on Diet and Health, American Dietetic Association, Institute of Food Technologies, US Army Surgeon General, National Aeronautics and Space Administration (NASA), the World Health Organization, United Nations Food and Agriculture Organization (FAO). Pope John XI has also endorsed the process as one solution to world hunger. In a recent special report requested by Congress, the General Accounting Office endorsed the benefits of irradiated food.

1.8 Why not just cook food thoroughly?

Cross-contamination of kitchen surfaces, which have been in contact with contaminated ground beef or chicken, can lead to food borne illness. For example ecoli left on a cutting board from contact with uncooked ground beef can then be transferred to say lettuce being chopped on the same cutting board, if it has not been thoroughly cleaned after the meat had been removed. Also, in many cases, food may not be cooked thoroughly as intended, because people are not properly trained, are in a hurry, or are distracted.

1.9 Does irradiated food need to be cooked?

Irradiation is a cold process that leaves food fresh, so you cook it just as you would any other food. While irradiation virtually eliminates harmful bacteria, the food is not made sterile. Proper handling procedures are still required or processors, retailers and consumers. Meat and poultry should be kept refrigerated. Contact surfaces, preparation implements and the cook's hands must be cleaned to prevent cross contamination.

1.9 Does irradiated food need to be cooked?

Irradiation virtually eliminates E. coli O157:H7, but there may be other contaminants, such as salmonella, which are more resistant and may not be eliminated. People who are at greater risk to food borne illness, such as the young, the elderly, or those with a compromised immune system should still exercise extra caution and have their hamburgers well done.

1.11 Why is hamburger irradiated & not steak?

Bacteria start off as a surface contamination on whole cuts of meat. When the meat is cooked, this surface bacterium is destroyed, even in the case of a steak which is left rare in the center. Because hamburger meat is ground, bacteria can be carried into the center where it may not be destroyed in cooking. While irradiation provides the greatest safety benefit for hamburger, it can also make whole meats safer by preventing cross contamination from surface bacteria.

1.12 How does irradiation affect shelf life?

Irradiation extends shelf life of food in two ways. First, it reduces spoilage bacteria and moulds that can grow even under refrigeration. Irradiated strawberries can last a week in the refrigerator without going moldy. Meat products can have shelf life approximately doubled in a similar fashion. The second way irradiation extends shelf life is by slowing the ripening process of fruits & vegetables. This can prevent potatoes from sprouting and keep mushroom caps from opening.

2. Commercial Questions

2.1 What is the irradiation process?

Electron beam Systems can be switched on or off at will, but like any other irradiation systems, electron beam systems require shielding. The electron generator is similar to the device at the back of a TV tube that propels electrons into the TV screen at the front of the tube. Food and other products are conveyed under the accelerator scan horn and are scanned with the electron beams. Electrons, from approved accelerator sources, can penetrate food to a depth of only one and one half inches. Two opposing beams can treat a little more than twice that thickness. Shipping cartons of food product are generally to thick to be treated with electron beams. Electron beam systems have been used to sterilize disposable medical devices for at least the last fifteen years.

X-ray systems can also be switched on or off at will. To produce useful quantities of X-rays a tungsten or tantalum metal plate, is attached to the end of the accelerator scan horn. The electrons strike the plate and are converted into X-rays, which pass through the metal plate and onto the product being conveyed underneath. The X-ray machine is a more powerful version of the machines used in many hospitals and dental offices. X-rays are photons, and have the advantage of being able to penetrate whole cartons of food product.

Gamma-ray systems operate continuously. When not in use for treating products, the gamma source is generally kept in a pool of water, which absorbs the radiation harmlessly and completely. To irradiate a product, the gamma source is pulled up out of the water into a shielded chamber and the products are transported around the source until the treatment is complete. Gamma-rays are photons and can penetrate whole cartons of food product. Gamma-ray systems have been used routinely, for more than forty years, to sterilize medical, dental, and household products.

2.2 Where in food processing will irradiation be used?

The actual process will either take place at the food processing facility, after packaging in initial boxes or final cartons, or at an Irradiation Service Center. Irradiation Service Centers have been irradiating medical devices, household products, and some food products, for decades to control bacteria. In all cases, the process will be run by certified personnel according to carefully tested protocols.

2.3 What other processes can control bacteria as alternatives to irradiation?

High Pressure processing, and other emerging technologies, may eventually have some use, but none are as easily implemented or as universally applicable as irradiation. The use of chemicals and even extraordinary sanitary measures at the food processing site cannot guarantee food free of disease causing microorganisms. Fumigants such as methyl bromide and ethylene oxide are often used on fruits and spices. Heat processing can sometimes be used, but may damage the product.

2.4 How does irradiation fit with HACCP?

Irradiation and HACCP are complementary weapons in the battle to ensure the safety of our food supply. HACCP is a plan, which identifies the hazards associated with each food item and determines how each hazard can be reduced or eliminated. Actual control of each identified hazard must then be accomplished by means of at least one 'roadblock' or 'critical control point' (or CCP) put in place at some point along the path between the farm and the consumer, to eliminate bacterial hazards. Irradiation is a technological intervention which can serve as a highly effective critical control point within the HACCP plan to eliminate microbial hazards. Planning alone cannot prevent microbial hazards from reaching the consumer; real intervention is required which actually kills the contaminating microorganisms.

2.5 How much radiation is used?

The amount of radiation used will be only that required to reduce the number of microorganisms on the food to a safe level. The radiation dose needed to enhance the safety of any particular food product will be carefully determined by testing and process validation. To make sure the taste of the food is maintained the amount of irradiation is kept as low as possible.

2.6 How does irradiation destroy bacteria?

Irradiation of any biological system, such as a bacterial cell, with ionizing energy leads to a portion of the incident energy being absorbed at random sites within the material of the biological system. At these sites the absorbed energy activates the absorbing molecules and gives rise to primary reactive species including ions, free radicals and excited molecules. These activated molecules have the ability to initiate chemical reactions with other molecules present in the system. The reactive species diffuse out of the sites of their formation and chemically attack various other biomolecules, including nucleic acids (DNA, RNA), membrane lipids, proteins, carbohydrates and others, causing damage to them. If the molecules which have been damaged ordinarily play a critical role in cell proliferation, then in their damaged form their ability to perform this vital function is lost, and the cell can no longer proliferate. Although the damage inflicted via the reaction cascade initiated by the primary reactive species afflicts all the major classes of biomolecules, scientific consensus is that cell killing is primarily due to damage to the DNA of the cell.

2.7 What is the cost of a typical irradiation facility?

Electron beam, X-ray and gamma ray food irradiation facilities are all multimillion dollar propositions. It is possible to install a small in-plant, or even "on-line" irradiation processing, but the cost will still be at least one to two million dollars. The cost per unit processed with these small systems is far higher than the unit processing costs in large irradiation facilities - due to slower throughputs.

3. Nutrition & Taste

3.2 Are irradiated foods still nutritious?

Food treated by irradiation is generally as nutritious as, or better than, the same food treated by the conventional, familiar processes such as cooking, drying, or freezing. Irradiation has no significant effect on the nutritional value of the macronutrients within foods (proteins, lipids, carbohydrates). Micronutrients, especially certain vitamins, can be reduced by irradiation, but these same vitamins generally are also subject to destruction by any or all of the other food processing methods commonly used on foods. Even simple storage can lead to major loss of certain vitamins. The significance of any loss of specific vitamins must be evaluated relative to the role of the irradiated food as a source of that particular vitamin in the diet of the consuming public. This consideration is heavily weighted by the regulatory agencies in their evaluation of petitions for clearance to irradiate any food. The FDA, WHO and American Dietetic Association have all considered the nutrition of irradiated food and endorsed the process.

3.3 How does irradiation affect the taste of food?

Any preparation process normally affects food taste. Any process, be it cooking, baking or irradiation, if improperly applied to a food can spoil that food. For this reason foods are generally processed according to a proven recipe. This is true also for irradiation processing, to make sure that the final product tastes good. The taste test serves as one of the major criteria guiding the development of a treatment protocol for any particular food. Food manufacturers obviously will not use any process, which changes the quality of the food to such an extent that it becomes unacceptable to consumers. There are many good examples of the excellent sensory quality of radiation processed foods, including the NASA menu items, which have been consumed by astronauts for many years.

4. Safety of Irradiated Food

4.1 Does irradiation make food radioactive?

No. As food is passed through the irradiation field, energy passes through the food much like a ray of light passes through a window. This energy destroys most of the bacteria that can cause disease, yet allows food to retain its high quality. Since the energy involved in irradiation is not strong enough to change the atoms of the food, and since the food never actually touches the radioactive source, the food can not become radioactive.

4.2 Is irradiated food safe?

Yes, in fact food is safer after being irradiated because the process destroys harmful bacteria that may be present. It has been studied more than any other food process over the last 50 years and is already approved in more than 37 countries. The Food and Drug Administration has checked the process from a nutritional, microbiological and toxicological perspectives, as have international bodies under the auspices of the United Nations. All proper scientific studies have found it to be safe and wholesome. This is why it is endorsed by a multitude of organizations, including the American Medical Association, the American Dietetic Association, the Mayo Clinic, and the World Health Organization.

4.3 Does eating irradiated food present long-term health risks?

No. The safety and effectiveness of food irradiation has been demonstrated in hundreds of studies and experiments. It is accepted by federal regulatory agencies and national and international food and public health organizations. The FDA has examined numerous studies on the chemistry of irradiated food, the impact of irradiation on the nutrient content of foods, potential toxicity concerns and effects on microorganisms in or on irradiated products.

Many hundreds of published research studies tried to identify problems from eating irradiated foods but failed to disclose any long-term health risks. Several of these studies were long term, multi-generation feeding studies, involving several species of test animals whose health and vitality were carefully monitored. The studies were reviewed by an international committee of independent experts representing a broad cross-section of scientific disciplines and institutions. They reviewed studies that claimed various possible health risks and determined that these studies either were lacking the proper scientific procedures to insure their results or have not been able to be duplicated by other scientists. A very complete review of scientific studies on the effects of irradiation on food is available in a report titled “High Dose Irradiation: Wholesomeness of Food Irradiated with Doses Above 10 kGy” released by the World Health Organization in 1999.

4.4 Are the chemical changes in irradiated foods, such as the formation of radiolytic products, harmful?

While Irradiation causes chemical changes producing so called "radiolytic products", there are no substances truly unique to irradiated foods. Evaluations of approximately 100 substances have found that they do not pose long term health risks. For example, most of the radiolytically generated compounds are present naturally in other (unirradiated) foods at levels which are many times greater than the levels generated by irradiation.

This conclusion of wholesomeness is reinforced by comparison of the chemical effects of irradiation with those of thermal processing. With few exceptions the chemical identities of the radiolytic products are identical to those generated 'thermolytically' by heating food, while their levels are generally much lower than is found in thermally processed foods. Thermally processed foods are safe; so are irradiated foods.

Finally, in a different but complementary approach based on function rather than chemistry, irradiated foods have been applied to various biological test systems, such as the Ames test for mutagens, or feeding the foods to test animals. Such tests have consistently failed to reveal the presence of mutagenic or other toxic principles in irradiated foods, strengthening the conclusion of safety.

4.5 Does irradiation create carcinogens like benzene in food?

Radiolytically produced benzene in irradiated foods is present at much lower levels than is found naturally in a variety of common foods, such as eggs or dairy products. Numerous carcinogenicity bioassay studies have been performed. These studies have not demonstrated any short term or long term toxicity related to the irradiation of food. Indeed, in the RALTECH study (the largest toxicology study ever conducted on irradiation or any other food processing method) the lowest incidence of cancer was found in the test groups that were fed the irradiated diets. This study was initiated by US Office of the Surgeon General, and the findings reviewed by the FDA and the National Toxicology Program's Board of Scientific Counselors who agreed that the evidence did not show any carcinogenicity.

The FDA has also reviewed data demonstrating that very low concentrations of benzene are produced by high dose radiation sterilization of beef – at doses 35 times that permitted by regulation. Analysis by expert scientists discloses that such low concentrations are of no health concern, and that foods irradiated at lower doses would present even less reason for concern.

4.6 Do the "free radicals" produced during irradiation affect the safety of food?

No. Free radicals can be formed when food is irradiated, as with other food processing methods and even the normal oxidation process in food. For instance, toasted bread (unirradiated) contains more free radicals than even very dry irradiated foods. A long term study in which animals were fed dry milk powder irradiated at more than four times the maximum approved dose failed to disclose any toxic effects over nine generations.

4.7 Does eating irradiating food cause genetic damage?

The claim of abnormal chromosomes resulting from eating irradiated food has been sensationalized as a result of a very small study done in the 1970's in India. The study reported increases in the frequency of polyploid cells in animals and malnourished children. Polyploidy means a multiple set of chromosomes; it is naturally occurring and varies among individuals. In the early 1980's eight studies with several irradiated food items were conducted in China. More than 400 people consumed irradiated foods for 7 to 15 weeks. No significant differences in chromosomal abnormalities were seen between the test and control groups.

4.8 Are irradiated foods sterile?

No, irradiation pasteurizes food by using energy, similar to pasteurizing milk using heat. In this process harmful bacteria will be destroyed thus making our food safer, but not sterile. The level of energy used does not kill certain spoilage organisms. This is for the protection of consumers as spoilage bacteria will multiply if the food is not properly handled and alert consumers not to use this particular food product. Food can be sterilized at higher irradiation doses, but other than spices, these are not commercially available in the United States. Irradiated food eaten by astronauts has been treated at high doses to make it sterile. Not all foods are suitable for radiation sterilization.

5. Safety of Irradiation Process

5.1 Is there a risk of radiation exposure if you live next to an irradiation facility?

No. Irradiation facilities must be built with sufficient shielding to prevent the ionizing radiation from escaping the facility even during normal operations. Additionally, when not in use, the radiation source is shielded also by water, concrete or metal shielding.

The transportation of radioactive material to the irradiation facility will not result in a risk of radiation exposure. The transportation safety record of the industry is excellent. While the radioactive sources are being transported, the source is contained in a cask that must meet very rigorous testing standards.

5.2 Do workers at irradiation facilities face dangers from radiation?

No. At all times, the radiation source is shielded by either water, concrete or metal. Irradiators are designed with several layers of overlapping protection to detect equipment malfunctions and to protect personnel from accidental radiation exposure. Potentially hazardous areas are monitored and a system of interlocks prevents unauthorized entry into the radiation cell when the source is exposed.

All irradiation facilities using radioactive materials must be licensed. Regulations require periodic inspections of facilities to insure compliance with the terms of the operating license. Non-compliance will result in severe penalties for the workers and the owners of the facilities.

5.3 Will there be risk from transportation of radioactive materials?

Radioactive material required for irradiators is transported in casks that prevent the release of radiation and/or radioactive material. The casks are designed to meet national and international standards modeled on the Regulations for Safe Transport of Radioactive Materials of the International Atomic Energy Act. The shipping cask must pass extensive tests before it can be used to ship radioactive material. These tests simulate accidents much worse than any cask would experience during transportation.

Large quantities of radioactive materials are safely shipped all over the world. For example, during a 35-year period in Canada, there were 870 separate shipments of cobalt-60 without any release of radioactive material. Over the same period, there were more than one million shipments of radioactive material in North America without an accident. The excellent safety record of this industry exceeds that of any other industry involved in shipping hazardous materials such as toxic chemicals, crude oil or gasoline.

5.4 Can an irradiation facility have a "melt down"?

No. It is impossible for a "meltdown" to occur in a gamma irradiator, or for the radiation source to explode. The source of ionizing radiation used in irradiators cannot produce neutrons. Neutrons are necessary for a "chain reaction" to occur to create a "meltdown". Electron beam and x-ray facilities contain no radioactive material.

5.5 What happens to the waste from an irradiation facility?

E-beam and X-ray irradiators have no waste to dispose of after processing.
In the case of gamma irradiators (cobalt-60 or cesium-137), the radiation sources decay over time into non-radioactive material; cobalt-60 to nickel, cesium-137 to barium. Generally, when the energy from the radioactive source falls to a low level, the source is returned to the supplier who will either use it for a customer with a lower energy requirement or store it until it is harmless. The amount of waste is minimal. It has been estimated that all of the cobalt-60 made in Canada in the last twenty years could be stored in a space the size of a desk.

The same process would take place when a facility closes. The sources can be returned to the supplier, sent to another customer, or stored. The machinery is dismantled and the building can be used for any purpose since no radiation remains. Electron beam and x-ray facilities do not generate radioactive waste.

5.6 Who makes sure irradiation facilities are operated safely?

Facilities using radioactive sources must be licensed by the Nuclear Regulatory Commission. To be licensed, the facility must demonstrate extensive and well documented safety design and procedures which will prevent the accidental exposure of workers or the public to radiation. The safe transport of radioactive sources is regulated by the Department of Transportation. E-beam and X-ray sources are not monitored by the NRC. Rather, the FDA, in conjunction with state authorities, oversees the regulation of these sources.

5.7 Have there been accidents at irradiation facilities?

Irradiation facilities have been operating in the United States for over thirty-five years without a single fatal accident. No events have been documented which resulted in the exposure of the general population to radioactivity. There have been a small number of fatal incidents in other countries where a worker ignored safety procedures and was exposed to the radiation source. In these cases, there was no danger to the public health or the environment.

6. Labeling & Regulatory

6.1 Which foods can be irradiated?

Many foods can be irradiated effectively including meat, poultry, grains, shell eggs, spices, fruits and vegetables. Irradiation is likely to have the greatest application for raw foods of animal origin. Examples of meat and poultry that may be irradiated are whole or cut-up birds, skinless poultry, pork chops, roasts, stew meat, liver, hamburgers, and ground meat. However, not all foods are suitable for irradiation. The following chart shows which food products have been approved for irradiation:

Table 1. Food products suitable for irradiation

Approval Year	Food	Dose	Purpose
1963	Wheat flour	0.20-0.50 kGy	Control of mold
1964	White potatoes	0.05-0.15 kGy	Inhibit sprouting
1986	Pork	0.30-1.00 kGy	Kill Trichina parasites
1986	Fruit and vegetables	1.00 kGy	Insect control,extend shelf life
1986	Herbs and spices	30.00 kGy	Sterilization
1990-FDA	Poultry	3.00 kGy	Bacterial pathogen reduction
1992-USDA	Poultry	1.50-3.00 kGy	Bacterial pathogen reduction
1997-FDA 2000-USDA	Meat	4.50 kGy	Bacterial pathogen reduction
2000-FDA	Shell eggs	3.00 kGy	Bacterial pathogen reduction

7. General

7.1 Do other countries irradiate food?

Over 40 countries allow irradiation of over 50 food types. It is estimated that over one billion pounds are irradiated annually. In addition to the US, other countries using irradiated food include Canada, France, Belgium, the Netherlands, Portugal, Israel, Thailand, Russia, China, South Africa and Brazil.

7.2 How can I find out more about food irradiation?

Documents on the safety and efficiency of food irradiation:

- Food Irradiation – Available Research Indicates That Benefits Outweigh Risks; United States General Accounting Office, (GAO/RCED-00-217), August 2000
- Irradiated Foods; Richard A. Greenberg; American Council on Science and Health, New York, NY, 1995
- High-dose Irradiation: Wholesomeness of Food Irradiated with Doses Above 10 kGy. WHO technical report series 890; World Health Organization, Geneva, 1999.
- Food Irradiation – A Guidebook; Morton Satin; Technomic Publishing, Lancaster, PA, 1996
- Safety of Irradiated Foods; J.F. Diehl; Marcel Decker Inc. New York, NY, 1990

The following web sites have useful information about food irradiation:

- American Dietetic Association: http://www.eatright.org/airradi.html
- United Nations: http://www.iaea.org/icgfi/
- U.S. Department of Agriculture - Food Safety and Inspection Service: http://www.fsis.usda.gov/OA/topics/irrmenu.htm

Further information on irradiation may be obtained from any Food Irradiation Processing Alliance member:

- FOOD TECHnology Service Inc., Mulberry, Florida (863) 425-0039
- GRAY*STAR, Inc., Mt. Arlington, NJ (973) 398-3331 www.graystarinc.com
- IBA, Memphis, Tennessee (901) 681-9006 www.iba.be
- MDS Nordion, Ottawa, Canada (613) 592-2790 www.mds.nordion.com
- Reviss Services / Puridec, Des Plaines, Illinois, (847) 795-8822 www.reviss.com
- STERIS Corporation, Mentor, Ohio (440) 354-2600 www.steris.com

7.3 Why is irradiation not more broadly used?

There are many reasons why irradiated food is not widely used at this time. One is that the approval for the major food products was only recently obtained while others, such as hot dogs & luncheon meats are still under petition. Thus there has not been a major demand because products have not been readily available to the public. A second reason is that irradiation is a sophisticated technology which takes time to integrate into the food processing industry. Irradiation facilities require significant investment and take time to install. Another reason is consumer acceptance. While surveys and market trials show that consumers are willing to buy irradiated food, it has not been generally available and so far there has been little promotion and education on the safety and benefits of irradiated food.

7.4 How should irradiated food be handled?

Like other food processes irradiation is not intended as substitutes for good hygienic practices. Consumers, stores and restaurants should follow the same careful handling and preparation procedures whether the food is irradiated or not.