Radiation meets food

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It's no secret that some people are wary of irradiated food. But radiation levels that effectively control pathogens have no demonstrated harmful effects on humans.

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The purpose of irradiating food is, quite simply, to improve quality. Illuminating a food with ionizing radiation can rid it of harmful pathogens and can also make it more aesthetically appealing. The essence of the process is that radiation disrupts a cell's chromosomal DNA; if the cell is unable to repair that lesion, it dies.

The food may be exposed to high-energy photons—gamma rays or x rays—or high-energy electrons. Radioactive isotopes such as cobalt-60 and cesium-137 produce gamma rays with suitable energies, but you need accelerators to generate the electron and x-ray beams used for food irradiation. Electron beams are produced by devices such as Van de Graaff generators and linear accelerators; x rays result when high-energy electrons produced by linear accelerators collide with a metal target. In principle, high-energy electrons, x rays, and gamma rays can instigate nuclear excitations that yield radioactive byproducts. However, the energies approved by the US Food and Drug Administration for food irradiation are too low to induce radioactivity.

Different doses for different purposes

Not surprisingly, the effect of radiation on food is related to the amount of ionizing energy absorbed. That quantity is measured in grays (Gy), named after physicist Louis Harold Gray, with 1 Gy being an absorbed dose of 1 joule per kilogram of material. Doses of less than 1 kGy prevent sprouting in potatoes and delay ripening of fruits. Such doses also serve to disinfect foods by killing insects in grains and fruits and inactivating parasites in meat—in particular, they can knock out the worm responsible for trichinosis.

Slightly higher doses of 1–5 kGy serve to pasteurize foods—that is, to kill many of the microorganisms that reside therein (see the figure). Radiation pasteurization, or radurization, significantly reduces or eliminates bacteria of public health significance in the food. *Salmonella*, the most often reported bacterial agent of foodborne illness, *Listeria monocytogenes*, and the harmful bacterial strain *Escherichia coli* O157:H7 are all very sensitive to irradiation. Indeed, in approving irradiation of poultry, the FDA strongly considered the sensitivity of salmonellae to irradiation and the relatively low doses that would effectively control them. Most of the current interest in and research on food irradiation has focused on the doses commonly used for radurization.

Organisms responsible for food spoilage are not so sensitive to radiation, so radurized food still needs to be refrigerated. But a dose beyond 25 kGy or so will sterilize food. Astronauts on space missions have dined on food sterilized by irradiation. On Earth, the food can be stored at room temperature just as canned goods are.

A particularly nice property of the irradiation technique is that it generates little heat. Raw meat still appears raw after the process and greens look and taste fresh. Moreover, irradiation can penetrate packaging material. Foods can be sealed first, then irradiated, an ordering that eliminates the risk of harmful contamination during packaging. Irradiated food need not include many additives that would otherwise be introduced to inhibit bacterial growth. And treating quarantined imported fruits and vegetables with radiation eliminates the need for toxic fumigants.

Consumer concerns

Nowadays, people are more aware of the food they eat than at any other time in history. Consumers' reactions to irradiated foods range from curiosity to concern about a process they don't fully understand to absolute rejection of the technology. Worries about food irradiation fall into two broad categories: radiation safety and food quality.

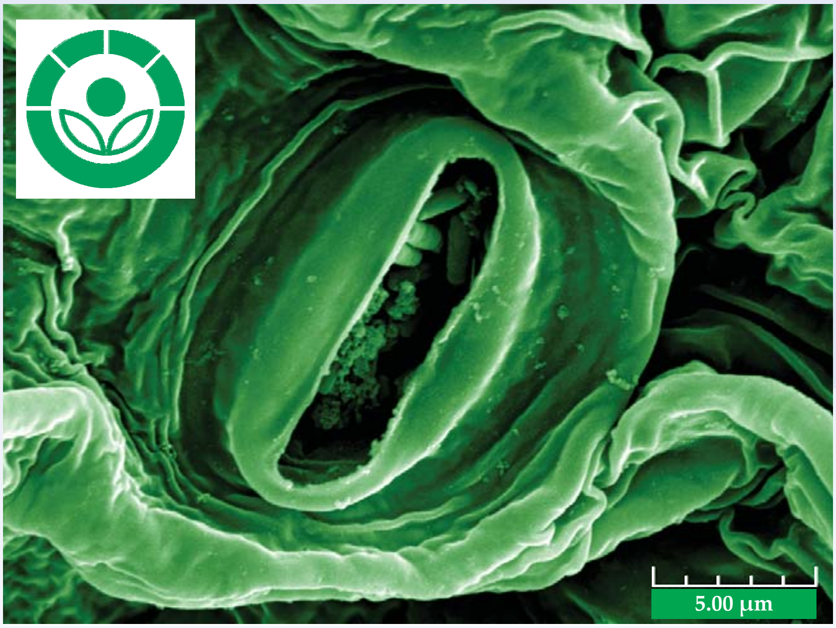
For many, the terms "radiation" and "radioactivity" have negative connotations. Even though the radiation sources approved by the FDA cannot make food radioactive, some people still worry about induced radioactivity. Scientists need to do a better job in communicating the facts to the public and putting that fear to rest.

Some people are concerned about what might happen as radioactive isotopes are transported from one location to another. The worry is reasonable, since an accident in transit can potentially contaminate the environment. The transportation segment of the nuclear industry, however, has an excellent safety record and is aware of public concern. The containers used to transport highly radioactive isotopes have been designed and constructed with the most severe of accidents in mind; according to the US Department of Energy, even if a transport truck strikes a concrete wall at 135 km/h, the containers won't be compromised. Indeed, radioactive materials are routinely and safely transported to meet medical needs.

Perhaps the more prevalent concerns relate to the quality of the food after irradiation. Some consumers worry that irradiation will be used to "salvage" spoiled food, others are concerned that irradiated food is poor in nutrients, and still others express anxiety about compounds generated in food during the irradiation process.

Since irradiation reduces the amount of bacteria in the food, it increases shelf life. As noted earlier, though, the organisms responsible for food spoilage are not as sensitive to radiation as are more lethal bacteria such as *Salmonella*. In any event, spoilage results from bacterial byproducts, not simply bacterial presence; radurization, like conventional pasteurization, does not get rid of those byproducts. If irradiation were used in an attempt to salvage spoiled milk, for example, the process would not fool the consumer; the milk would still smell and taste bad.

Consumer concerns about nutrient loss in irradiated foods are understandable. Irradiation does reduce vitamin



Capsule-shaped *Escherichia coli* bacilli lurk in the pore of a lettuce leaf. In 2008 the US Food and Drug Administration approved the use of irradiation to kill such bacteria in lettuce; other techniques aimed at eliminating them are not as effective. (Electron micrograph courtesy of Rosana Moreira, biological and agricultural engineering department, Texas A&M University.) The inset shows the international Radura symbol; US law requires it to appear with all irradiated foods, along with a label indicating that the food has been irradiated.

levels in foods, especially for the B group vitamins. Thiamine is particularly sensitive, and as much as half of that vitamin can be destroyed in food irradiated at high doses. Vitamin loss, however, occurs in many food processes, including cooking and canning. The real issue is how vitamin loss from irradiation compares with that from cooking or other preservative processes and, in particular, if the removal of vitamins through irradiation can lead to dietary deficiencies. Cooked, irradiated food does have a slightly lower vitamin content than food that has not been irradiated prior to cooking. For meats, the additional elimination of vitamins is of relatively little consequence, since cooked meats are generally not consumed for their vitamin content. For vegetables, the loss of vitamins is potentially of greater concern. The FDA, however, considers change in nutritional value as part of its evaluation of irradiation processes. The agency is not permitted to approve the use of irradiation if it will result in a significant nutritional loss. For example, at the doses approved for quarantine control of fruits and vegetables—below 1 kGy—more than 90% of the vitamins remain in the produce.

Freedom of choice

The ultimate consumer concern with any new food process is the safety of the processed food. Without doubt, applying radiation to a food breaks molecular bonds and thus generates radiolytic byproducts. But such common processes as pasteurization, cooking, and canning also induce chemical changes. For 30 years now, food scientists have been trying to determine whether irradiation creates any byproducts that are not caused by other common (and, by the way, rarely tested) processes. After three decades, we haven't found any, though we can't say with certainty that they don't exist.

Over the years, food scientists in the US and other countries have conducted numerous toxicological studies. In 1980 a joint committee of the United Nations Food and Agriculture Organization, the International Atomic Energy Agency, and the World Health Organization endeavored to evaluate all the studies on the wholesomeness of irradiated food. The final report concluded that "the irradiation of any food commodity up to an overall average dose of 10 kGy presents no toxicological hazard; hence, toxicological testing of foods so treated is no longer required." The conclusions of that report continue to hold up to scientific scrutiny.

Nonetheless, a 2008 incident in Australia involving irradiated cat food caught the public eye. As part of the Australian quarantine requirements, the food was irradiated with a dose of at least 50 kGy. Several cats who ate the irradiated food suffered paralysis, and more than a dozen ultimately died. The cause of the illnesses was never fully identified, but the manufacturer of the tainted pet food put the blame for the cats' illnesses on the irradiation process. However, all pet food imported into Australia is either heated or irradiated, and the malady was linked to one specific lot of cat food from one specific brand. No illness was associated with other brands of irradiated cat food or even with previously irradiated batches of the same brand of cat food. The overwhelming consensus in the scientific community is that the problem was specific to the lot, not the irradiation process.

The scientific evidence to date indicates that irradiation does not produce any toxicity in foods. Still, consumers have the right to make their own informed choices. For the foreseeable future, consumers will retain the option to select nonirradiated foods; indeed, at present it's the irradiated meat, poultry, or produce that is hard to find. In any case, shoppers can readily distinguish between the irradiated and nonirradiated varieties in the supermarket: Those foods that have been irradiated must, by US law, display the internationally recognized Radura symbol shown in the figure, accompanied by the words "treated by irradiation" or "treated by ionizing radiation."

The online version of this Quick Study includes a capsule history of food irradiation.

Additional resources

▶ J. H. Skala, E. L. McGown, P. P. Waring, "Wholesomeness of irradiated foods," *J. Food Prot.* **50**, 150 (1987).

▶ D. R. Murray, *Biology of Food Irradiation*, Wiley, Hoboken, NJ (1990), chap. 4.

▶ R. W. Lacey, *Hard to Swallow: A Brief History of Food*, Cambridge U. Press, New York (1994), chap. 7.

▶ Joint FAO/IAEA/WHO Study Group on High-Dose Irradiation, *High-Dose Irradiation: Wholesomeness of Food Irradiated with Doses Above 10 kGy*, WHO technical rep. 890, World Health Organization, Geneva (1999), online at http://www.who.int/foodsafety/publications/fs_management/en/irrad.pdf.

▶ J. S. Smith, S. Pillai, "Irradiation and food safety," *Food Technol.* **58**(11), 48 (2004).

▶ B. Marler, "Pros and cons of commercial irradiation of fresh iceberg lettuce and fresh spinach: A literature review," http://www.marlerblog.com/uploads/file/ProsandConsIRR.pdf. ■