Food Irradiation Still Faces Hurdles

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The 1991 opening of an irradiation plant in Mulberry, Florida, has sparked renewed interest in food irradiation. Unlike the 40 or so existing gamma-irradiation plants in the United States used to sterilize disposable medical supplies and for other industrial uses, the Florida irradiator is the first to specialize in treating food.

In January 1992, Vindicator, Inc., shipped an initial 1,000 pints of irradiated strawberries to a Florida grocery store. Packaging the strawberries in a high carbon-dioxide atmosphere and irradiating them extended their shelf-life. According to the store owner, the strawberries maintained their fresh appearance and market quality for 22 days instead of the usual 3 to 5 days.

The grocery store owner said most customers were indifferent about the irradiation treatment. Most purchased the strawberries labeled "Treated by Irradiation" when the nonirradiated strawberries were more expensive. He said a small number of shoppers refused to buy the irradiated strawberries, while an equal number praised the store for offering irradiated produce. That store, and two others in Ohio and Illinios, sold irradiated strawberries and other fruit and vegetables in 1992.

As of 1991, 37 countries, including the United States, allow irradiation of specific foods. However, in only about 20 of these countries is food irradiated on a commercial basis—mostly to decontaminate small quantities of spices. Companies in a few countries also irradiate potatoes, onions, poultry, seafood, or grain. According to the American Spice Trade Association, less than 1 percent of U.S. spices are irradiated and used in processed foods. Irradiation has also been used to sterilize food for U.S. cancer patients and astronauts.

How Irradiation Works

Irradiation exposes products to ionizing radiation—gamma rays from radioactive isotopes (most commonly, cobalt-60) or machine-

Unlike most industrial irradiation facilities, this Florida plant specializes in treating food.

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produced, high-energy electrons and x-rays. Irradiated foods do not become radioactive when irradiated with FDA-approved sources. The effects of the radiation depend on the dose absorbed, measured in kilograys (kGys) (table 1).

Irradiation Offers a Variety of Benefits . . .

Irradiation sterilizes or kills insects infesting grain and produce. Low-dose irradiation also inhibits sprouting of potatoes, onions, and other root crops and can delay ripening of some tropical fruit. Higher doses can kill micro-organisms that cause spoilage in fresh foods. Thus, irradiation may replace chemical fumigants, sprout inhibitors, and postharvest fungicides. Irradiation also kills salmonellae and other micro-organisms that can contaminate meats and poultry and cause foodborne diseases, such as salmonellosis and campylobacteriosis.

Irradiation is a "cold treatment" that achieves its effects without raising the food's temperature significantly, leaving the food closer to its unprocessed state. By not using high temperatures, irradiation minimizes nutrient losses and changes in texture, color, and flavor.

Table 1
Food Irradiation Presents Benefits and Limitations

Suggested dose	Benefits	Limitations	Status
Kilograys			
0.05-0.15	Inhibit sprouting of root crops and elongation of asparagus	Potatoes must cure before irradiation	Approved by U.S. regulators
0.30-0.75	Sterilize insects	Reinfestation possible, insects still able to feed	Approved by U.S. regulators
0.10-0.75	Delay ripening of some fruit	Successful for limited number of fruit	Approved by U.S. regulators
0.30-0.50	Inactivate parasites in meat	Still needs refrigeration	Approved by U.S. regulators for pork only
1-2	Kill spoilage micro-organisms in fish and fungi in fruit	Recontamination possible. Still need refrigeration. Above certain doses, softening, pitting, and other problems for fruit	Not approved by U.S. regulators
1.5-3	Reduce micro-organisms causing public-health problems in meat and poultry	Recontamination possible. Still need refrigeration.	Approved by U.S. regulators for poultry only
10-30	Decontaminate spices	Recontamination possible	Approved by U.S. regulators
23-57	Sterilize food for unrefrigerated storage	Must be irradiated to minimize undesirable changes in quality	Not approved by U.S. regulators

. . . and Limitations

One limiting factor for irradiation is damage to the food. Irradiating fresh produce can cause softening, sensitivity to chilling, uneven ripening, and rot. Very few fruit tolerate the doses needed to control postharvest fungi. Medium doses may create off-flavors in radiation-sensitive meats. Irradiation leaves no protective residues, so proper packaging is needed to prevent recontamination by insects or micro-organisms. Meats, poultry, and fish irradiated at low or medium doses still require refrigeration.

Irradiation May Improve Food Trade

Irradiation may enhance exports or imports, provided the recipient country accepts the irradiated food. A longer shelf-life extends the geographic market for fresh products by providing extra time to reach distant markets or by allowing the use of a slower, and thus cheaper, mode of transportation.

Quarantine treatment is another use for irradiation. Such treatments help prevent the spread of plant pests to noninfested areas. For example, exports of U.S. citrus, papayas, and cherries to Japan are treated with vapor heat, are held at low temperatures (cold treatment), or are fumigated with methyl bromide. U.S. imports of many fruit are subject to similar treatment. However, methyl bromide has been found to deplete the ozone layer, and is targeted for phase out by the U.S. Environmental Protection Agency (EPA) before the end of the decade.

USDA researchers have shown irradiation to be an effective quarantine treatment in ridding Florida grapefruit of Caribbean fruit flies. But irradiation cannot be used as a quarantine treatment on grapefruit because USDA's Animal and Plant

Health Inspection Service (APHIS) has approved irradiation to treat only Hawaiian papayas for shipment to the continental United States, Guam, Puerto Rico, and the U.S. Virgin Islands.

FDA and FSIS Permit Low-Dose Irradiation

Use of irradiation on foods requires the approval of the U.S. Food and Drug Administration (FDA). USDA's Food Safety and Inspection Service (FSIS) must approve use for meats and poultry. (APHIS must approve irradiation when used as a quarantine treatment for animal and plant products.)

In the early 1960's, FDA approved low-dose irradiation for white potatoes to stop sprouting and for wheat and wheat flour to control insects. U.S. growers and food manufacturers have not used either application because less expensive and easier-to-use chemicals have been available.

In the early 1980's, FDA approved doses of 10 kGy to kill microorganisms in spices and dried-vegetable seasonings. In July 1985, FDA approved low doses (0.3 to 1.0 kGy) to sterilize trichinae in infected pork. FSIS gave its approval to irradiate pork in January 1986.

In April 1986, FDA approved doses up to 1 kGy to control insects in foods and to delay ripening and sprouting in fresh fruit and vegetables. FDA also raised the level permissible for spices and dried-vegetable seasonings to 30 kGy.

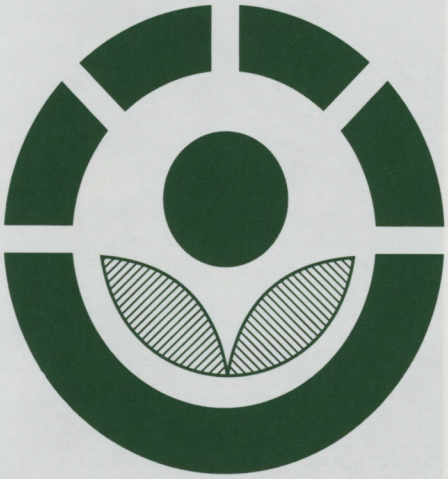
FDA's most recent regulatory action allows irradiation of poultry at doses of up to 3 kGy to control salmonellae and other pathogens in poultry. FSIS approved irradiation of poultry in September 1992 (see "Irradiation of U.S. Poultry—Benefits, Costs, and Export Potential" elsewhere in this issue).

Irradiated Foods Must Be Labeled

Government regulations require irradiated food at the retail level to be labeled "Treated with Radiation" or "Treated by Irradiation," and to bear the international logo for irradiated food.

For irradiated foods that are not packaged, such as bulk containers of fruit and vegetables, retailers must display prominently the required logo and phrase. Retailers may place the phrase and logo on the bulk container, on counter signs or cards, or on individual fruit or vegetables. Irradiated foods sold at the wholesale level must be labeled, and the caution "do not irradiate again" is required on the shipping container as well as on either the invoice or the bill of lading.

Labeling requirements apply only to whole foods that have been irradiated. Foods containing irradiated ingredients, but which are not themselves irradiated, are exempt from labeling. For example, irradiated strawberries would be required to carry the logo and phrase, but yogurt containing irradiated strawberries would not. Labeling regulations do not apply to food served in restaurants.



Irradiated foods must display this international symbol.

Surveys Show Consumers Wary . . .

Uncertainty over consumer acceptance of irradiated foods is one of the major roadblocks for the technology. A major consumer concern with irradiation is its perceived association with radioactivity and nuclear power. Several food manufacturers and retailers say they are willing to use irradiation when consumers are ready to accept the process.

In its annual consumer-attitudes survey, the Food Marketing Institute asks shoppers whether they consider irradiated foods to be a health hazard. Respondents who considered irradiated foods a serious hazard grew from 37 percent in 1986 to 42 percent over the 1989-91 period. By 1992, concern with irradiated foods as a serious hazard dropped to 35 percent. The percentage of respondents saying they were unsure about the hazard of irradiated foods grew from 18 percent in 1991 to 27 percent in 1992.

. . . But Test Marketing Demonstrates Consumer Acceptance

While opinion surveys generally find consumers wary of irradiated foods, small-scale test marketings demonstrate consumers are willing to buy irradiated produce—and even sometimes pay a premium price.

In 1984, EPA banned ethylene dibromide (EDB), one of the major pesticides used to kill insects in imported fruit and vegetables. No satisfactory alternative existed for killing fruit flies in Caribbean-grown mangoes, so Puerto Rican mangoes could not enter mainland United States.

In 1985, APHIS gave permission for a small shipment of Puerto Rican mangoes to be disinfested by irradiation and to enter the mainland United States. The mangoes were sold in the same Florida grocery that later sold the irradiated strawberries. Shoppers paid premium prices for the irradiated mangoes. And, repeat sales were common.

Two supermarkets in the Los Angeles suburbs offered irradiated Hawaiian papayas at the same price as hot-water disinfested papayas in 1986. Irradiated papayas outsold hot-water treated papayas by more than 10 to 1. (The irradiated papayas were riper because hot-water treatment requires harvesting the fruit just as it starts to ripen.)

In a more recent marketing test, Central Missouri State University researchers sold irradiated and nonirradiated apples at local roadside stands. Prices for the irradiated apples varied ($0.29, $0.39, and $0.49 per pound), while the nonirradiated apples were priced at a constant $0.39 per pound. Some bought the irradiated apples out of curiosity or because they thought irradiated apples tasted better and could last longer. Most buyers responded to price, purchasing whichever apples were cheaper.

Food Irradiation Opponents Vocal

Opponents of food irradiation may be fueling consumer apprehension about irradiation. One anti-food-irradiation group sponsored radio spots in Florida implying that irradiated fruit and vegetables might kill anyone who eats them.

Opponents object to the use of a technology dependent on a radioactive material for environmental and worker safety reasons. Some have threatened boycotts against manufacturers and retailers who handle irradiated foods. They assert that the long-term safety of eating irradiated food has not been proven and question whether irradiation lessens the nutritional value of the treated food.

Irradiated Foods Not Easily Detectable Without Labels

The lack of reliable post-irradiation techniques for detecting irradiated foods may be adding to public mistrust of the process. Several types of dosimeters exist for determining the amount of radiation a food receives while in the irradiation chamber. But once the food leaves the chamber, the reduction of bacteria is the only easily discernible difference between some irradiated and nonirradiated foods.

Scientists are working on a variety of post-irradiation testing methods to determine if a product has been irradiated and at what dose. The most promising tests are for products containing fatty acids, bone, or chitin, such as poultry or shrimp. However, these screening methods are still in the development or verification stage.

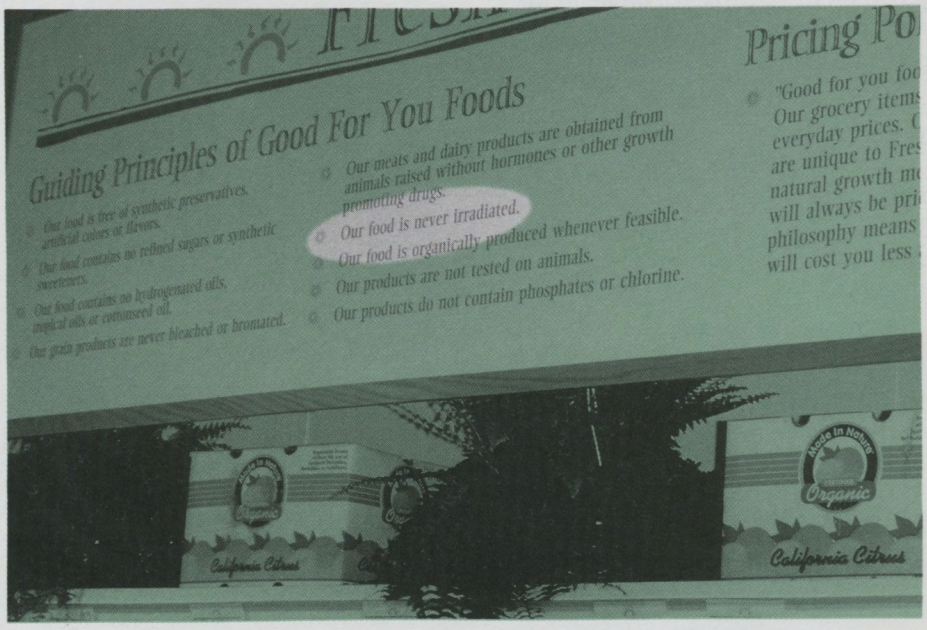
Public Concern Sparks Restrictive Actions

Maine and New York prohibit the sale of irradiated foods, with the exception of spices and sterilized food for hospital patients with compromised immunity. Officials of these two States have said the action was in response to lobbying by citizen groups and not the result of scientific evidence questioning the safety of food irradiation.

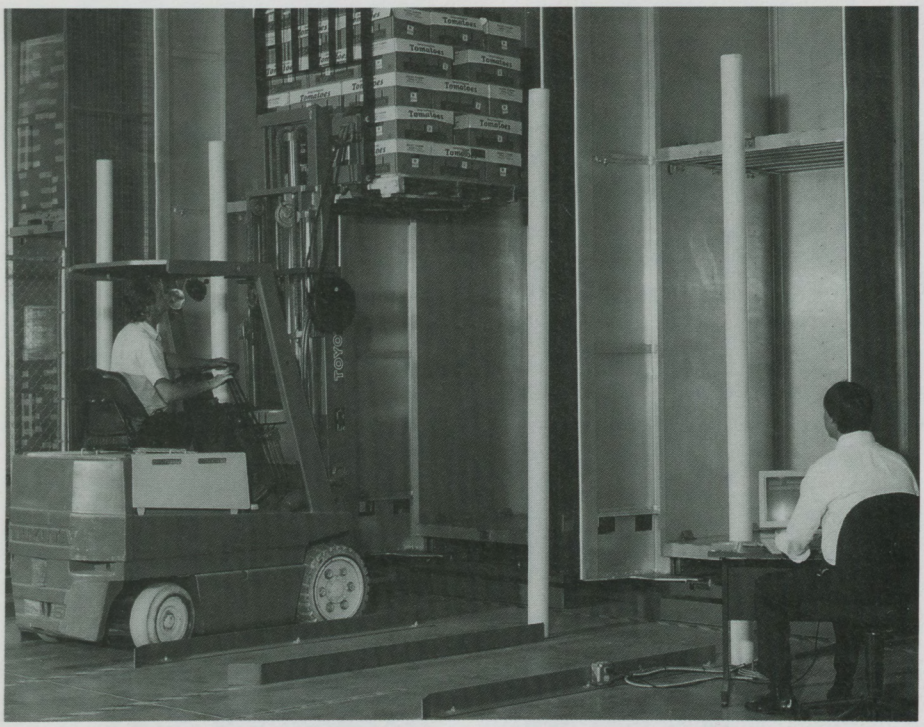
In the past, legislatures in other States—including Alaska, California, Massachusetts, New Hampshire, and Pennsylvania—had introduced resolutions or legislation that would ban or restrict the irradiation of foods. But, these proposals were not passed.

Costs Also Limit Use

Irradiation is capital-intensive. USDA's Economic Research Service (ERS) estimated that building an irradiator designed to treat one type of food (single-purpose facility) in 1988 would have required a minimum initial investment of $3 million. Sam Whitney, president of the Vindicator irradiator, reports



Consumer acceptance is one of the main roadblocks for the technology.



Irradiating produce to control insects is more costly than chemical fumigation. An irradiator must treat 50 million pounds of food a year to bring costs down to 1-3 cents per pound.

that his first plant, which can treat a variety of foods, cost $7.8 million to build and load with cobalt-60—the radiation source. Duplicate facilities would cost somewhat less.

ERS found that an irradiator must treat 50 million pounds of food a year to bring treatment costs down to 1-3 cents per pound. (For additional cost information, see "Irradiation's Potential for Preserving Food," *National Food Review*, Spring 1986.) Firms that do not have the volumes to justify building their own irradiator as part of their packing or processing plant will either have to join with other firms and build a freestanding, centrally located irradiator or use the services of a contract irradiator.

The president of Vindicator reports that irradiating the strawberries for the Miami store added 30 cents to the cost of a dozen pints—or about 3 cents per pound. In addition to the irradiation cost, with a freestanding or contract irradiator there is also the expense of transportation.

Irradiation must compete with existing preservatives and fumigants by providing either a superior or a lower cost treatment. Preliminary comparisons show irradiation to be more costly than chemical treatments. ERS estimates that irradiating produce for insect control runs 1-4 cents per pound, higher than the reported 0.3-2.3 cents per pound for chemical fumigation.

Irradiation Faces Competition From Other New Technologies

Food scientists continue to develop and refine alternative methods to extend shelf-life and improve food quality. For example, USDA and Israeli researchers have copatented three new yeast strains that have proven effective against certain postharvest rots that strike citrus fruit, grapes, apples, pears, and tomatoes. A private company is developing these yeasts for commercial use.

New developments in packaging—such as shrink-wrapping and modified-atmosphere storage—can also extend shelf-life. For example, Fresh Western Marketing Inc. in Salinas, California, uses a breathable plastic patch to regulate the rate at which oxygen and carbon dioxide enter and leave the packaged fruit and vegetables. The company uses this controlled-atmosphere packaging to sustain the quality and to more than double the shelf-lives of a variety of fresh fruit and vegetables, including asparagus, broccoli, cauliflower, lettuce, snowpeas, tomatoes, and berries.

This process and other packaging technologies may achieve the shelf-life extension that irradiation offers at a lower cost and a higher degree of public acceptance.

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