Irradiation

It Could Become A Food Preservation Technology for the 1990's

by Rosanna Mentzer Morrison and Tanya Roberts

After 40 years of research and regulatory scrutiny, food irradiation now faces its true test—the marketplace. Last year the U.S. Food and Drug Administration (FDA) issued its first blanket approval of low dose irradiation to control insects and extend shelf life of foods. In 1985, FDA approved irradiation to control the parasite in pork that causes trichinosis.

But the big questions remain. Will regulators approve higher doses? Will processors invest millions of dollars in irradiation plants? Will consumers buy and eat irradiated foods? For irradiation to become a food preservation technology for the 1990's, all three groups must buy the idea. Although we might anticipate consumer resistance to the thought of eating "nuked food," the recent microwave experience suggests such barriers of perception can be overcome.

Regulators Approving More Uses

Although irradiation offers a variety of food applications, regulators throughout the world have been cautious about approvals. However, as knowledge of radiation chemistry and experimental information accumulates, regulators seem to be increasingly satisfied that foods irradiated at low doses are safe to eat.

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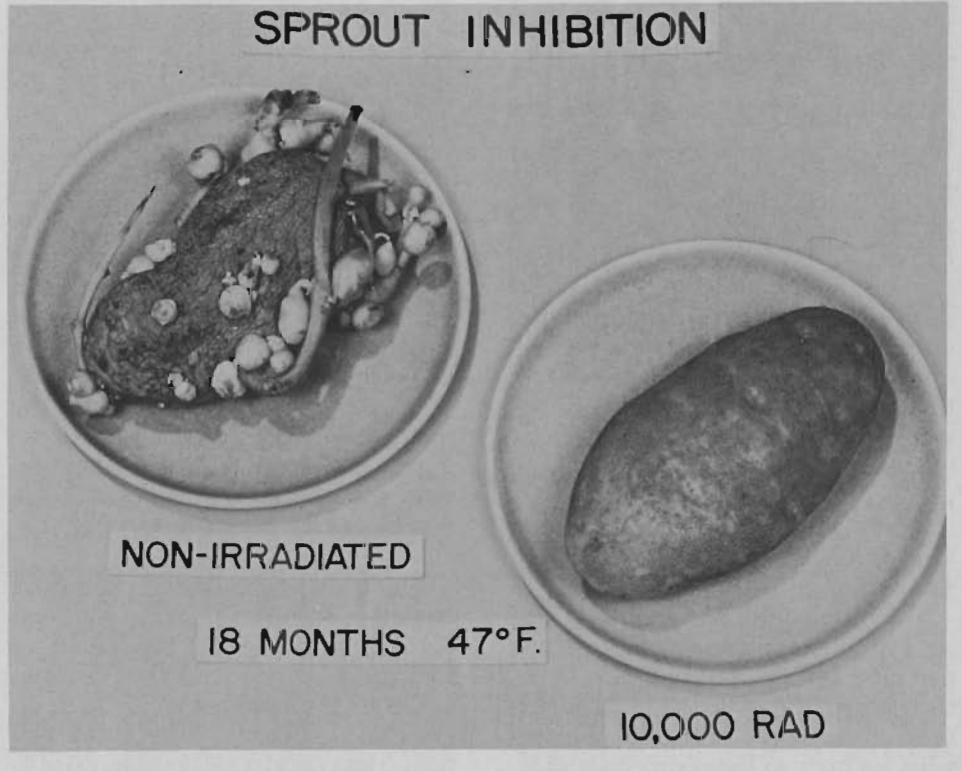


Also, pressure to approve irradiation has risen as food losses and health problems associated with insects (in fruits and spices), parasites (such as trichinae in pork), and bacteria (such as salmonella in poultry and beef) receive more press attention.

In 1983, the Codex Alimentarius Commission, an arm of the United Nations, gave irradiation a giant boost by recommending that countries permit irradiation of any food with doses up to 1,000 kilorads (krads). All food applications, except food sterilization, are covered by this recommendation.

The U.S. Environmental Protection Agency's 1984 ban on ethylene dibromide (EDB) as a post-harvest fumigant caused the agricultural community to look at irradiation with renewed interest. Hawaiian papaya growers were particularly hurt by the ban on EDB used to

kill fruit flies. In April 1986, FDA approved irradiation up to 100 krads, one-tenth of the Codex recommendation. This dose range kills or sterilizes insects for quarantine purposes, disinfests grain, inhibits sprouting of potatoes and other root crops, delays ripening of tropical fruits such as papayas and mangoes, and inactivates trichinae in pork to reduce human trichinosis.

FDA also approved one high dose use: 3,000 krads to clean up spices and dried vegetable seasonings. Untreated spices can contaminate processed foods, causing spoilage and foodborne disease. FDA was willing to approve a higher dose for spices because they are such a small part of the diet.

FDA is considering approvals above 100 krads on a case-by-case basis. While irradiation does not make food radioactive, FDA wants to be sure that nutrients would not be destroyed, toxic compounds would not be formed, the risk of botulism would not increase, or other deleterious effects would not occur. Currently, FDA is reviewing a petition from USDA's Food Safety and Inspection Service (FSIS) to use 150 to 300 krads to reduce the pathogens in poultry that cause human intestinal illnesses.

The cautious approach of the FDA has caused other countries to revise their positions. Australia was moving toward adopting the Codex recommendations, but consumers questioned why Australia was on a faster track than the United States. In response, the Australian government has called for additional reviews of food irradiation's safety.

Food Companies Hesitating

What does irradiation offer growers and food companies? For selected foods, possible benefits might be enhanced quality, chemical-free fumigation, a safer product, or a longer shelf-life.

—Enhanced Quality. Today, spices in processed products are the only irradiated foods in the U.S. marketplace. Irradiation preserves flavor and color better than the alternative treatments of heating and gassing. In addition, the irradiation cost is a small percentage of the value of spices. In the case of spices, the issue of consumer acceptance is not a market factor because FDA does not require processors to disclose irradiated ingredients on labels of prepared foods.

New products and processes often accompany a new technology. With irradiation some possibilities include: faster aging of wine, nitrite-reduced bacon, more tender beef, and shorter rehydration time and improved quality for dehydrated foods.

—An Alternative Quarantine Treatment. Banning EDB focused immediate attention on irradiation as a substitute method for sterilizing fruit flies in papayas and mangoes. The doses needed for produce and grain fall under FDA's 100-krad maximum and generally do not damage the commodities. Imported and exported commodities are well suited to irradiation since large quantities are consolidated at a shipping point where an irradiator could be built. Reinfestation is not a concern because treated products, such as mangoes, are sent to an area free from the particular pest. However, irradiation's use on exports depends on the importing country accepting irradiation as a satisfactory quarantine treatment.

The recent problems with salmonella could change this situation.

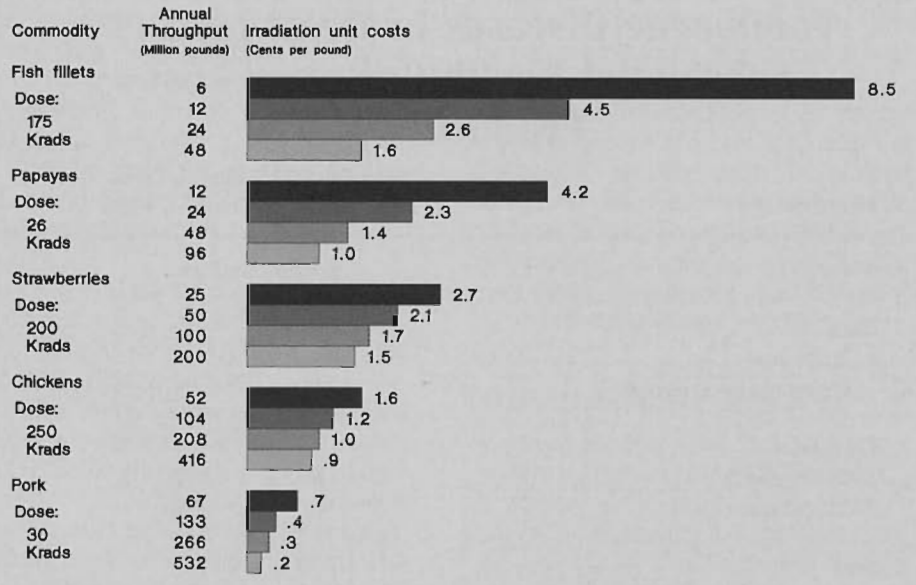
—Safer Food. Foodborne disease causes millions of illnesses and thousands of deaths annually in the United States. As shown in the table we estimate that irradiation could save annually $1 billion of productivity losses and medical costs associated with four diseases transmitted through meats. This conservative estimate excludes other costs, such as pain and suffering and lost leisure time. Trichinae control in pork has been approved, but irradiated pork is not yet in the supermarkets.

Other pathogen control uses require higher doses, not yet approved by FDA and FSIS. Shrimp may be an early international trade candidate since high salmonella contamination often causes shipments to be refused entrance into the United States and other countries.

Most consumers and regulators are not now demanding that meat and poultry meet microbiological standards. But the recent problems with salmonella could change this situation. With FDA approval, private initiatives, such as aggressive marketing of low-salmonella poultry, could set a norm other firms may be forced to meet. Success with poultry could lead to irradiation of other meats and fish. It could also lead to an increase in branding for meats as companies seek to identify irradiation's benefits with their brand names.

—Shelf-life Extension. Shelf-life extension has the power to open new markets for fresh foods domestically and in-

Figure.
Irradiation Treatment Costs



Costs are based on a specific set of assumptions and input prices listed in Morrison and Roberts.

GRAPH BY DOUG PARRY, DIVISION OF INFORMATION, ERS

ternationally. A 7 to 10 day longer shelf-life for irradiated fish could expand its geographic market and allow high-valued fresh fish to be trucked rather than flown to U.S. cities far from fishing areas. Mushrooms, strawberries, and cut flowers are other highly perishable products that tolerate irradiation and could similarly expand their markets. However, FDA has not approved the moderate doses needed to reduce spoilage fungi and microbes, and many fruits and vegetables are damaged by these doses. Also, the efficient food distribution and storage systems in the United States already extend shelf-life, so that further extensions may be of little value.

These benefits are not without costs. Irradiation must compete with other food processing techniques by offering a superior product or a lower cost treatment. Our estimates of unit costs, derived from the experience of irradiators used to sterilize medical supplies, are often less than packaging costs.

Investment costs for the radiation source, building space, machinery, and other physical assets ranged from $1 million for a facility treating 6 million pounds of fish a year to $11.2 million for an irradiator treating over 400 million pounds of chicken annually.

Treatment costs shown in the figure, which include annualized capital and operating costs, varied from 8.5 cents per pound for a facility designed to irradiate small volumes of fish fillets to 0.2 cent per pound for an irradiator treating a large volume of pork. Treatment costs per pound rise with higher doses and lower volumes.

We estimated irradiation to reduce trichinosis to cost less than a penny per pound of pork. Reduction of pathogens in chicken was more, but less than 2 cents a pound. Irradiation of papayas to sterilize fruit flies ran between 1 and 4 cents a pound. Reduction of fungi on strawberries doubles their shelf-life and is estimated at 2 cents a pound. Doubling the shelf-life of fresh fish with irradiation ran between 2 and 8 cents a pound.

Processors, cooperatives, and slaughterhouses often handle annual volumes sufficient to capture irradiation's economies of scale. Our research found that economies of scale became less pronounced at annual capacities between 30 to 50 million pounds. Most U.S. chicken and hog slaughtering plants have sufficient volumes to install an in-house irradiator. Fresh fruit and vegetable growers may lack the volumes to justify their own irradiators, but cooperatives may handle these volumes. Also, growers could join together and build a centrally located irradiator to treat their combined harvests. Another option is to locate a contract irradiator at a port or shipping point and treat several growers' products for a fee.

For free-standing irradiators (not part of the packing house) and contract facilities, the cost of shipping products to the irradiator is an added cost not included in the estimates. As free-standing irradiators increase in size, they will have to draw from larger geographic areas for

Food Irradiation

What Is It?

Irradiation is a process where products are exposed to ionizing radiation to achieve a variety of effects. In foods, radiation sterilizes or kills insect or microbial pests by damaging their genetic material and forming substances toxic to the organism. Irradiation also slows ripening and sprouting in fresh fruits and vegetables by interfering with cell division.

Irradiation is a "cold treatment." It achieves its effects without raising the temperature of the product significantly, usually leaving the food closer to its unprocessed state than canning or freezing.

The effects of radiation on the product depend on the dose absorbed, usually measured in kilorads (krads). Applications range from inhibiting sprouting of potatoes to sterilizing a food so it will keep in unrefrigerated storage. A major problem is that often the dose needed to kill the pest damages the food. Moderate doses may soften and pit fruits and vegetables and create off-flavors and odors in radiation-sensitive meats.

Food irradiation uses gamma rays from radioactive isotopes or machine-produced, high energy electrons and x-rays. The gamma rays from cobalt-60 or cesium-137 cannot make the food radioactive. FDA has established maximum energy levels for machine irradiators to prevent inducing radioactivity in the treated food.

Foodborne Diseases in Meats Lead to Substantial Health Costs and Lost Productivity

Meat/Disease	Associated U.S. Health Costs and Productivity Losses, 1985
	million dollars
Pork	
Trichinosis	$ 1 to $ 3
Congenital toxoplasmosis	215 to 323
Chicken	
Salmonellosis	64 to 115
Campylobacteriosis	362 to 699
Beef	
Salmonellosis	209 to 374
Total	**$851 to $1,514**

products. Consequently, transportation costs to the larger irradiator may outweigh its gains in production economies.

Producers of seasonal fruits and vegetables will likely face higher treatment costs than these estimates. Irradiators built to accommodate seasonal peaks would have excess capacity during the off season. This increases treatment costs because of the irradiator's high fixed costs relative to variable costs. Locating an irradiator in an area with sequential harvests for different irradiation-compatible commodities, or irradiating nonagricultural items during off seasons, would lessen this under-utilization problem.

Consumers Inexperienced

Food companies face a dilemma. They recognize irradiation's potential payoff. Imagine the market appeal of a fresh strawberry that does not rot in a few days, or a pork roast that poses no danger of trichinosis, even if undercooked. At the same time, companies fear consumers will reject irradiated foods. They are reluctant to risk the reputation of their brand name by associating it with the process.

Consumer acceptance of food irradiation depends on their confidence in regulators, awareness of irradiation's benefits, and separating any fear of nuclear power from food irradiation. Perhaps acceptance will follow the path of microwave ovens where initial skepticism and health concerns were not sufficient to prevent their becoming a kitchen mainstay.

Most U.S. chicken and hog slaughtering plants have sufficient volumes to install an in-house irradiator.

U.S. consumers cannot routinely purchase irradiated foods in supermarkets today. Test marketing of irradiated mangoes last fall at Laurenzo's Italian Center in North Miami Beach found shoppers paying premium prices for a premium product. Even though mangoes were clearly identified as "treated by irradiation," repeat sales were common. FDA requires that irradiated foods be labelled "treated by irradiation" or "treated with radiation" and bear the international logo.

A 1985 survey revealed most U.S. consumers (55 to 65 percent of the population) are confused about irradiation and uncertain about eating irradiated foods; 25 to 30 percent think they understand the technology and generally trust its safety; but 5 to 10 percent do not trust its safety and feel it conflicts with their antinuclear stance or preference for organic foods. Food irradiation opponents can be very vocal, and they have threatened to organize boycotts against supermarkets selling irradiated food. Such protests could cause previously neutral or positive consumers to reject irradiated food.

Conclusions

Astronauts and cancer patients today eat irradiated foods for their shelf-life extension, palatability, and pathogen reduction features. Restaurants, fast food outlets, and institutional kitchens may be next, if willing to pay for longer shelf-life. Also, sales to restauranteurs avoids labelling concerns because menus do not have to identify irradiated items. The improved food properties possible with irradiation, such as microwaveable pork and faster rehydration time for dried vegetables, may be more readily accepted and demanded by food service companies and processors looking for ways to save money and diversify menus and product lines.

Any technology must be competitive. Even though FDA approved irradiation of wheat and potatoes in the 1960's, cheaper chemical alternatives have kept irradiation in the laboratory. As a disinfestation treatment for mangoes and papayas, our estimates of 1 to 4 cents per pound for irradiation are greater than the reported 0.3 to 2.3 cents per pound for chemical fumigation.

For irradiation to become an important food preservation technique in the 1990's, its benefits must be valued enough to cover costs and to allay the concerns of consumers and food industry managers. Irradiation awaits further approvals by regulators and ultimately, the test of the marketplace.

Its Applications and FDA Approvals

Dose in krads	Benefits	Limitations	FDA Approval
5-75	Sterilizes insects.	Reinfestation possible. Insects still able to feed	1963, 1986
5-15	Inhibits sprouting of root crops and elongation of asparagus.	Potatoes must cure before irradiation	1964, 1986
10-75	Delays ripening of some fruits.	Successful for limited number of fruits.	1986
30-50	Inactivates parasites in meat.	Still need refrigeration.	1985 (trichinae)
100-200	Kills spoilage micro-organisms in fish and fungi in fruits.	Recontamination possible. Still need refrigeration. Above certain doses, softening, pitting, and other problems	Petition submitted for fish
200-400	Reduces micro-organisms causing public health problems in meat and poultry.	Recontamination possible. Still need refrigeration. Above certain doses, off-flavor and color problems.	Under review for chicken
2,300-5,700	Sterilizes food for unrefrigerated storage.	Must be irradiated frozen to minimize undesirable changes in quality.	Only spices approved, 1983 and 1986

For Additional Reading

Congressional hearings on food irradiation contain the full report by Morrison and Roberts. Ask for Serial No. 99-14, Committee on Agriculture, U.S. House of Representatives. Also, see the December 1985 issue of the American Journal of Agricultural Economics for the public health benefit assessment.