Irradiation of Food

A PUBLICATION OF THE INSTITUTE OF FOOD TECHNOLOGISTS' EXPERT PANEL ON FOOD SAFETY AND NUTRITION

This Scientific Status Summary addresses the current state of scientific knowledge of the technology, with emphasis on muscle foods.

The Food and Drug Administration's (FDA) approval of irradiation for red meats in December 1997 ended a long chapter in the tumultuous history of an important food safety and preservation technology. Federal acceptance validates what food scientists have long known: that appropriate absorbed doses of radiation effectively kill disease-causing bacteria and delay food spoilage. When irradiated ground beef becomes available, consumers once again may enjoy their hamburgers rare or medium rare. Low doses of radiation can kill at least 99.9% of Salmonella in poultry and an even higher percentage of Escherichia coli O157:H7 in ground beef.

This summary briefly addresses the remaining questions about food irradiation. In addition, it provides a useful summary of the regulatory history and the current state of scientific knowledge of the technology as applied to food. Federal regulators, food scientists, food processors, and consumers will write the next chapter in the story of irradiation. New challenges awaiting resolution include safely and successfully implementing irradiation in the meat and poultry processing industries; maintaining the quality of raw, irradiated meats; developing packaging suitable for irradiation; developing methods to detect irradiated foods; and educating the public about the wholesomeness of foods made safer by irradiation.

Regulatory Acceptance and Commercial Application

Research on the application of ionizing radiation to food began in earnest in the early 1950s. This processing technology was ready to be commercialized by the late 1950s. In the United States, however, passage of the Food Additives Amendment to the Food, Drug, and Cosmetics Act in 1958 effectively delayed the commercialization of irradiation for three decades. The Food Additives Amendment classified sources of radiation as food additives. The amendment, thus, required an authorizing regulation prescribing safe conditions of use and pre-market review and acceptance by the FDA. The agency has authorized ionizing radiation for several specific food uses, shown in Table 1.

Although irradiation of medical devices and disposables has a long history of use (Derr, 1993), irradiated foods were not produced commercially in the United States until 1992. Irradiation is cleared for use on at least one food product in 35 countries, and irradiated foods are commercially available in 28 developing as well as developed countries (IAEA, 1995; Loaharanu, 1996). Spices are the most commonly irradiated food. Other commercially-available irradiated foods include a variety of fruits and vegetables, rice, potatoes, onions, sausage, and dried fish (in Bangladesh only). At least one irradiated muscle food (meat, poultry, and seafood) is cleared for use in 18 countries, including Chile, France, and the Netherlands.

The number of retail outlets offering irradiated foods and the amount of irradiated foods commercially available in the United States has grown slowly. Only four retail stores in the United States continuously offer irradiated foods. Use of irradiated foods has grown slightly faster in the food service sector, primarily in hospitals for reducing the potential for cross contamination in food preparation and for immune-compromised patients.

Effects of Irradiation

Irradiation exposes food to a source of ionizing radiation sufficient to create positive and negative charges. The amount of radiation energy absorbed is measured in units of grays (or kilograys, kGy). One gray equals one joule per kilogram. Radiation sources approved for food use are gamma rays (produced by the radioisotopes cobalt-60 or cesium-137), machine generated X-rays (with a maximum energy of 5 million electron volts, MeV), and electrons (with a maximum energy of 10 MeV). Depending on the dose of radiation energy applied, foods may be pasteurized to reduce
or eliminate pathogens, or they may be sterilized to eliminate all microorganisms, except for some viruses (Crawford and Ruff, 1996; IFT, 1983). For example, low (up to 1 kGy) to medium doses (1–10 kGy) kill insects and larvae in wheat and

<table>
<thead>
<tr>
<th>Product</th>
<th>Dose (kGy)</th>
<th>Purpose</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat, wheat flour</td>
<td>0.2 - 0.5</td>
<td>Insect disinfection</td>
<td>1963</td>
</tr>
<tr>
<td>White potatoes</td>
<td>0.05 - 0.15</td>
<td>Sprout inhibition</td>
<td>1964</td>
</tr>
<tr>
<td>Pork</td>
<td>0.3 - 1</td>
<td>Trichinella spiralis Control</td>
<td>1989</td>
</tr>
<tr>
<td>Enzymes (dehydrated)</td>
<td>10 max.</td>
<td>Microbial Control</td>
<td>4/18/86</td>
</tr>
<tr>
<td>Fruit</td>
<td>1 max.</td>
<td>Disinfection, Ripening Delay</td>
<td>4/18/86</td>
</tr>
<tr>
<td>Vegetables, fresh</td>
<td>1 max.</td>
<td>Disinfection</td>
<td>4/18/86</td>
</tr>
<tr>
<td>Herbs</td>
<td>30 max.</td>
<td>Microbial Control</td>
<td>4/18/86</td>
</tr>
<tr>
<td>Spices</td>
<td>30 max.</td>
<td>Microbial Control</td>
<td>4/18/86</td>
</tr>
<tr>
<td>Vegetable Seasonings</td>
<td>30 max.</td>
<td>Microbial Control</td>
<td>4/18/86</td>
</tr>
<tr>
<td>Poultry, fresh or frozen</td>
<td>3 max.</td>
<td>Microbial Control</td>
<td>5/2/90</td>
</tr>
<tr>
<td>Meat, frozen, packaged</td>
<td>44 min.</td>
<td>Sterilization</td>
<td>3/8/90</td>
</tr>
<tr>
<td>Animal Feed and Pet Food</td>
<td>2 - 25</td>
<td>Salmonella Control</td>
<td>9/28/95</td>
</tr>
<tr>
<td>Meat, uncooked, chilled</td>
<td>4.5 max.</td>
<td>Microbial Control</td>
<td>12/2/97</td>
</tr>
<tr>
<td>Meat, uncooked, frozen</td>
<td>7.0 max.</td>
<td>Microbial Control</td>
<td>12/2/97</td>
</tr>
</tbody>
</table>

* For meats used solely in the National Aeronautics and Space Administration space flight programs.

wheat flour and destroy pathogenic bacteria and parasites. Low to medium doses also inhibit sprouting of potatoes and other foods and slow the ripening and spoilage of fruit. Higher doses (10–50 kGy) sterilize foods for a variety of uses such as for astronauts during space flight and immune-compromised hospital patients who must have bacteria-free food.

When molecules absorb ionizing energy, they become reactive and form ions or free radicals that react to form stable radiolytic products (Woods and Pikaev, 1994). The Council for Agricultural Science and Technology (CAST, 1989) estimated that a dose of 1 kGy would break fewer than 10 chemical bonds for every ten million bonds present, an extremely small percentage. Cooking, or applying infrared radiation to foods, produces similar changes in chemical bonds.

Even though an extremely small percentage of chemical bonds are broken when a food is irradiated, the effect can be dramatic. For example, breaking bonds in the deoxyribose nucleic acid (DNA) results in the loss of a cell’s ability to replicate. A relatively small change in the DNA of a bacterial cell can destroy the cell. The cellular destruction caused by disruption of the genetic material in a living cell is the principal effect of radiation on food (Murano, 1995a), enabling destruction of insects, inactivation of parasites, delaying of ripening, and prevention of sprouting. Ionization of radiation cannot make food radioactive.

The physical laws that govern the nature of chemical reactions and the stability of chemical substances are the same whether the enhanced molecular reactivity created by heat energy is supplied by infrared radiation, microwaves, ionizing radiation, or other sources (CAST, 1986). The radiolytic products that form when food is irradiated are generally the same as those that are formed when food is cooked. Investigators developing methods for detecting irradiated foods have identified alkylcyclobutanes in some irradiated foods that were not detected in unirradiated samples. These substances may serve as markers for irradiated foods. Despite concerns expressed by those who decry the use of radiation, no unique radiolytic products of toxicological significance have been found in irradiated foods (Crawford and Ruff, 1996).

Wholesomeness

Pauli and Tarantino (1995) prepared a comprehensive review of the information FDA requires to establish the safety of proposed applications of radiation. The agency considers four broad areas: radiological safety, toxicological safety, microbiological safety, and nutritional adequacy (Table 2). With radiological safety, the question is whether radioactivity will be induced in the food. This issue is of no concern for the currently approved radiation sources because their energy is too low to induce radioactivity.

The issue of toxicological safety raises the questions: (1) Is there evidence of adverse toxicological effects that can be attributed to toxic substances produced by irradiating the food? (2) What should be tested? (3) What tests provide useful information? The questions are difficult to address because radiation leads to the absorption of ionizing energy rather than the addition of a substance. The toxicological safety of food additives has traditionally been assessed by animal feeding studies and involves determining the highest dose of a substance that causes no toxicological effects, and the application of safety factors to account for individual variability and uncertainty in extrapolating from animals to humans (Pauli and Tarantino, 1995).

To assess the changes caused in foods by irradiation and recommend toxicological testing requirements for assessing their safety, the FDA formed the Bureau of Foods Irradiated Food Committee (BFIFC). Because no evidence of toxicity attributable to irradiation of food was found, the committee recommended that foods irradiated at doses less than 1 kGy, or foods representing only a very small fraction of the diet, should be exempt from requirements for toxicological testing. FDA then organized a task group to assess animal feeding and mutagenicity studies. The group concluded that toxic effects are not expected from foods irradiated at doses below 1 kGy and concurred with the recommendation of the BFIFC. Because available data were not adequate to evaluate the safety of irradiation of all foods at doses greater than or equal to 1 kGy, the task group also recommended that the agency consider authorizations of the process on a case-by-case basis for foods that are consumed in significant amounts or that are irradiated at higher doses. Hence, the poultry petition that was cleared by FDA in 1990 (9 CFR Part 381) was considered separately because the petition requested radiation dose levels greater than 1 kGy.

With the red meat petition, however, the concept of chemi-generic clearance was used. This concept is that radiation
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The chemistry of the constituent components (e.g., water, protein, lipid, carbohydrates) among a food group produces common and predictable stable drates) among a food group produces similar radiolytic products. The database of the poultry petition can thus be used to address toxicological questions about different meat species and fish. For foods to be irradiated above 1 kGy, FDA's principal interest is with the conditions for food irradiation (temperature, packaging atmosphere, dose range) and their impact on microbiological safety and nutritional adequacy.

The issue of microbiological safety of irradiated foods raises many questions; the two most important are: (1) Can irradiation mutate microorganisms, producing more virulent pathogens? (2) Will irradiation reduce the numbers of spoilage microorganisms, allowing pathogens to grow undetected without competition? FDA does not consider radiation-induced mutation a concern with respect to increased virulence or heat resistance since there is no evidence for such effects. In fact, radiation is much more likely to reduce the virulence of any surviving pathogens (Farkas, 1989). FDA requires evidence that radiation, under realistic conditions, achieves the intended microbiological effect without allowing Clostridium botulinum to grow and produce toxin undetected.

The two most important questions of nutritional adequacy of irradiated foods are: (1) Does irradiation result in a significant loss of any nutrient in the food under the proposed conditions of use? (2) Is the food proposed for irradiation an important dietary source of the affected nutrient? Many food processes, like cooking, alter nutrient content much more than irradiation. Trace elements and minerals are not affected by irradiation. Macronutrients such as protein, carbohydrates, and fats are not significantly affected by doses up to 10 kGy. Even with sterilization doses of 50 kGy, macronutrient losses are small and non-specific (Diehl, 1995; WHO, 1994).

Some vitamins, however, are sensitive to radiation. The amount of vitamin loss due to food irradiation is affected by several factors, including dose, temperature, presence of oxygen, and food type. Generally, radiation at low temperatures in the absence of oxygen reduces any vitamin loss in foods, and storage of irradiated foods in sealed packages at low temperatures also helps prevent future vitamin loss (WHO, 1994).

Not all vitamins have the same sensitivity to irradiation. For water soluble vitamins, the order of sensitivity is generally: thiamin > ascorbic acid > pyridoxine > riboflavin > folic acid > cobalamin > nicotinic acid. For fat soluble vitamins, the order of sensitivity is generally: vitamin A > carotene > vitamin K > vitamin D (WHO, 1994).

FDA requires that the affected vitamin(s) in the irradiated food are not significant in the overall diet. The nutritional significance of vitamin loss due to irradiation depends on the level of loss and the proportion of the irradiated food in the diet. It is doubtful that any vitamin deficiency would develop from consuming irradiated foods. For example, pork is a major source of thiamin, the most radiation sensitive water-soluble vitamin, but only 2.3% of thiamin in American's diets would be lost if all the pork in the United States were to be irradiated (CAST, 1996).

The most recent World Health Organization (WHO) review of the safety and nutritional adequacy of irradiated foods concluded that food irradiation: (1) will not lead to toxicological changes in the composition of food that would have an adverse effect on human health; (2) will not increase microbiological risk; and (3) will not lead to nutrient losses that would have an adverse effect on the nutritional status of people (WHO, 1994). Furthermore, a meeting of the Food and Agriculture Organization of the United Nations, International Atomic Energy Agency, and the World Health Organization (WHO) concluded on the basis of knowledge derived from over 50 years of research that irradiated foods are safe and wholesome at any radiation dose (WHO, 1997).

Irradiation of Muscle Foods

- Microbiology. As with cooking and thermal processing, higher radiation doses kill greater numbers of bacteria. The D values (decimal reduction, or dose required to destroy 90% of the microorganisms present) of several pathogenic bacteria may be associated with raw meat and poultry are shown in Table 3. Salmonella is the most resistant non-sporing pathogen, with a D value of about 0.6 kGy. The radiation doses approved for poultry, 1.5-3.0 kGy, would destroy about 99.9% (3 logs) to 99.999% (5 logs) of Salmonella. Except for spores of Clostridium botulinum, all other

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Table 2 Information Required by the U.S. Food and Drug Administration To Establish the Safety of Irradiated Food

<table>
<thead>
<tr>
<th>Considerations</th>
<th>Question(s)</th>
</tr>
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<tbody>
<tr>
<td>Radiological Safety</td>
<td>Will radioactivity be induced in the food?</td>
</tr>
<tr>
<td>Toxicalogical Safety</td>
<td>Is there evidence of adverse toxicalogical effects that can be attributed to toxic substances produced by irradiating the food?</td>
</tr>
<tr>
<td></td>
<td>What should be tested?</td>
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<tr>
<td></td>
<td>What tests provide useful information?</td>
</tr>
<tr>
<td>Microbiological Safety</td>
<td>Can irradiation mutate microorganisms, producing more virulent pathogens?</td>
</tr>
<tr>
<td></td>
<td>Will irradiation reduce the numbers of spoilage microorganisms, allowing pathogens to grow undetected without competition?</td>
</tr>
<tr>
<td>Nutritional Adequacy</td>
<td>Does irradiation under the proposed conditions of use result in a significant loss of any nutrient in the food?</td>
</tr>
<tr>
<td></td>
<td>Is the food proposed for irradiation an important dietary source of the affected nutrient?</td>
</tr>
</tbody>
</table>

From Pauli and Tarantino (1995)
pathogenic bacteria listed in Table 3 would be controlled within this dose range. A minimum dose of 1.5 kGy would destroy at least 6 logs of *E. coli* O157:H7, which has a D value of about 0.24 kGy. Irradiation, therefore, would be extremely effective at eliminating this pathogen, declared an adulterant in ground beef in 1994. The parasites *Toxoplasma gondii* and *Trichinella spiralis* are inactivated at doses of 0.25 kGy (Dubey et al., 1986) and 0.3 kGy (Brake et al., 1985), respectively.

Although the primary objective of irradiation of muscle foods is destruction of pathogenic bacteria, substantial reduction of spoilage microorganisms also occurs. Niemand et al. (1983) reported that levels of aerobic and anaerobic bacteria were reduced by over four logs and almost five logs, respectively, in chilled ground beef irradiated at doses to 2.5 kGy. Shelf life of the ground beef stored at 4°C was extended by nine days, before counts reached seven logs. The refrigerated shelf-life of vacuum-packaged beef sirloin cuts irradiated to 2 kGy more than doubled, from about four weeks for non-irradiated product stored at 0°C to 10 weeks for irradiated product stored at 4°C (Niemand et al., 1981). Lefebvre et al. (1992) reported a three log reduction in psychrotrophic aerobic bacteria in ground beef irradiated at 2.5 kGy. The irradiated ground beef had a shelf-life of ten days before counts reached seven logs compared with the non-irradiated control which lasted only one day.

Lambert et al. (1992) found that pork loin slices packaged under nitrogen and irradiated to 1 kGy had a 26-day shelf-life (21 days more than the control) stored at 5°C. Thayer et al. (1993) found that un inoculated ground pork, irradiated at 1.9 kGy, had no surviving bacteria when stored at 2°C for up to 35 days.

The predominant food spoilage organisms are Gram-negative psychrotrophic microorganisms that are very susceptible to radiation (Monk et al., 1995). Several researchers have shown that irradiation of food at doses of at least 1 kGy virtually eliminate Gram-negative microorganisms, but has a much smaller effect on Gram-positive lactic acid-producing microorganisms (Dempster, 1985; Ehioba et al., 1988; Lambert et al., 1992; Mattison et al., 1986; Niemand et al., 1983; Thayer et al., 1993). *Pseudomonas* species and *Enterobacteriaceae*, common spoilage bacteria, are easily eliminated even with low doses of radiation. However, in all of these studies at doses in the range of 1–5 kGy, Gram-positive microorganisms survived and caused spoilage after prolonged refrigerated storage.

• **Quality.** Irradiation may affect the quality of meat by processes other than those attributable to microorganisms. Radiation dose, dose rate, temperature and atmosphere during irradiation, and temperature and atmosphere during storage can all affect the outcome of specific foods (Thayer, 1990). Radiolytic products can cause oxidation of myoglobin and fat, leading to discoloration and rancidity or other off-odor or off-flavor compounds (Murano, 1995b). Ozone, a strong oxidizer, is produced from oxygen during food irradiation and may oxidize myoglobin, causing a bleaching discoloration.

Some scientists have observed that irradiated raw meat developed an off-odor compared with the non-irradiated control (Lefebvre et al., 1994; Lynch et al., 1991). Sudarmadji and Urbain (1972) reported that the threshold dose for irradiation odor ranged from 1.5 kGy for turkey to 6.25 kGy for lamb. Niemand et al. (1981) reported that an irradiation odor was detected but not objectionable in raw beef irradiated at low dose. Cooking appears to reduce or eliminate any irradiation-induced odor (Kropf et al., 1995; Luchsinger et al., 1996). Odor resulting from irradiation may thus be important only in raw meat. Further investigation would enable full characterization of irradiation-induced odor and better understanding of the conditions that affect its development.

Irradiation can also cause some color changes in meat, that are greatly influenced by the packaging environment. For example, irradiated vacuum-packaged meat can develop a fairly stable brighter red or pink color in pork, beef, and turkey breasts (Lebepe et al., 1990; Lynch et al., 1991; Niemand et al., 1983). In the presence of oxygen, however, irradiation can cause discoloration. Grant and Patterson (1991) observed discoloration in pork irradiated in the presence of oxygen. Irradiation of frozen grass prawns at 10 kGy reduced levels of polyunsaturated fatty acids (C18:2 and C18:3) by 25–32%, possibly due to oxidation and decomposition of lipids into volatile compounds (Hau et al., 1992). The threshold dose for development of irradiation flavor in the frozen grass prawns was 4.5 kGy.

The extent of chemical changes that occur in the frozen state is less than that in non-frozen food due to decreased mobility of free radicals. With less mobility in the frozen state, free radicals tend to recombine to form the original substances rather than diffuse through the food and react with other food components (Taub et al., 1979). Irradiating foods at appropriate doses and under certain conditions, such as in a reduced oxygen or oxygen-free atmosphere, packaging, and the frozen state, can minimize or avoid the development of objectionable off-odors and flavors. Irradiated meat will be successful in the market place only if consumers are satisfied with its sensory quality.

• **Packaging.** To obtain the full benefit from the potential to reduce levels of microorganisms, eliminate pathogens, and prevent cross-contamination, muscle foods should be packaged before irra-
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Radiation. Irradiation of packaging film may result in evolution of gases, such as hydrogen, and production of low-molecular weight hydrocarbons and halogenated polymers (Kilcast, 1990). The impact of irradiation on the packaging material itself must, therefore, be considered (Lee et al., 1996).

Materials used to package foods before irradiation must be accepted for such use by the FDA. Acceptable materials are listed in 21 CFR 179.45. Any coextruded or laminate multicomponent films, commonly used for packaging non-irradiated muscle foods, must be accepted by FDA before use in food irradiation.

At radiation doses accepted for food, only low-molecular weight polymers and gases have the potential for migration into the product and influencing product quality. Taint-transfer problems, for example, have been observed when the commonly used fresh meat overwrap polyvinylchloride (PVC) was irradiated at 3.9 kGy (Kilcast, 1990). PVC, however, is not accepted by FDA for use in food irradiation. Antioxidants used in packaging films may also be significantly degraded, although migration of antioxidants into the food product has not been observed (Buchalla et al., 1993).

The suitability for food irradiation of new types of polymeric packaging material, including co-extrudates and multilayer laminates requires further investigation. In addition, additives, adhesives, and printing materials should also be screened (Kilcast, 1990). Determination of the threshold level of migration of film components, resins, and additives is required to expand the availability of FDA-approved polymeric films. With FDA approval of individual film components, film manufacturers would be able to develop film structures that would have de facto FDA approval without having to petition for approval of each new film structure.

Detection of Irradiated Foods

Development of food irradiation detection methods, useful for regulatory compliance purposes, is an active area of investigation. Stevenson (1992) reviewed progress of several methods. Detection methods would likely accelerate approval of additional food irradiation applications and would enhance international trade of irradiated foods.

Because there are no major chemical, physical, or sensory changes in irradiated foods, detection methods must focus on minute changes. Gildewell et al. (1993) prepared a comprehensive review of over 200 references relating to detection methods for irradiated foods. Generally, detection methods focus on chemical, physical, histological, morphological, and biological changes in the foods.

Lipids and DNA are particularly sensitive to ionizing radiation. Crone et al. (1992) detected 2-alkyl-cyclobutone, a cyclic compound formed from fatty acids in irradiated but not cooked lipid-containing foods. An interlaboratory comparison of the cyclobutone method correctly identified, with no false positives, 99% of 134 samples (ADMIT, 1994). Detection of hydrocarbons from irradiated lipid-rich foods is also a promising detection method. In an interlaboratory comparison of irradiated and non-irradiated chicken, 93% of 239 samples were correctly identified. False negative results occurred only in samples irradiated at 0.5 kGy (ADMIT, 1994).

DNA base damage, single-strand and double-strand DNA breaks, and crosslinking between bases are the main effects of irradiation. Detection and quantification of these DNA changes should be of interest for determining that an uncooked food has been irradiated. Further development is needed to distinguish irradiation-induced DNA changes from those caused by other processing treatments (Stevenson, 1992).

Techniques for detecting measurable changes in physical properties of foods, such as cell membrane damage, hold potential. Detection methods for membrane damage include measurement of electrical impedance, viscosity, electric potential, electron spin resonance, and thermal and near-infrared analysis (WHO, 1994). Havashi (1988) reported that electrical impedance may be effective in determining irradiation of potatoes. Electron spin resonance appears effective for detecting irradiated bone-containing food and possibly shellfish (Derosiers, 1989; Grav and Stevenson, 1989).

Thermoluminescence (TL) has been successfully used to identify over 20 irradiated spices (Heide and Bogl, 1990). Sanderson (1991) demonstrated that contaminated minerals in spices are responsible for their TL. The use of TL for field crops, such as vegetables, fruits, and grains, would be possible, as they all contain some minerals (WHO, 1994).

Changes in cell structures due to irradiation may be measurable by histological and morphological methods. Measuring the percentage germination of viable seed in fruits and the microscopic changes in cell structure could indicate whether the food has been irradiated. Because such measurements can take from days to weeks to complete, the methods may be impractical.

Determining the ratio of viable to total (viable and dead) bacteria on a food using aerobic plate count and the direct epifluorescent filter technique could determine if the food has been irradiated (WHO, 1994). The technique becomes limited, however, if the initial contamination before irradiation is very low, radiation dose is very low, or the food was irradiated to delay ripening rather than to pasteurize. Differences in radiation sensitivity of Gram-negative bacteria and Gram-positive bacteria may be useful. If a large number of Gram-positive bacteria, which are not as sensitive to irradiation as Gram-negative bacteria, are found on a food concurrent with a very low number of Gram-negative bacteria, it is likely that the food has been irradiated. The assumption would have to be made, however, that the initial bacterial contamination on the food is a normal mix of Gram-negative and Gram-positive microorganisms.

In summary, there are several promising techniques to screen and detect a few irradiated foods. No one technique is likely to be applicable to all food materials. Methods likely to become internationally accepted protocols are hydrocarbon and cyclobutone for lipid-containing foods, electron spin resonance for bone-containing food, and thermoluminescence for foods containing silicate.
minerals. Considerably more collaborative work is necessary to develop universally accepted methods for detecting irradiated foods of all types.

**Labeling**

Prior to the passage of FDA reform legislation (Public Law 105-115) in November 1997, irradiated foods at the wholesale level were required to bear either the phrase "Treated by irradiation, do not irradiate again" or "Treated with radiation, do not irradiate again." At the retail level, food labels were required to bear the international radura symbol along with either of the statements "treated with radiation" or "treated by irradiation." The regulation for these labeling requirements (FDA, 1986), issued by FDA under its statutory authority within the Federal Food Drug and Cosmetic Act, permitted additional statements about the purpose of the treatment process and the type of radiation used in the treatment. The food provisions of the 1997 FDA reform legislation directed the agency to review its labeling rule and, as appropriate, revise it so that the disclosure statement is not more prominent than the declaration of ingredients. The radura symbol was not excluded as a means of making an irradiation disclosure.

**Consumer Acceptance**

Irradiated foods marketed in numerous countries were judged superior by consumers and have sold well (Bruhn, 1995). The successful sale of these products, although limited to four stores in the United States, shows that consumers will accept irradiated food. Large segments of the population, however, have not had the opportunity to purchase these foods. Communication with consumers is believed to be critical for expansion of irradiated food markets. Consumer acceptance of irradiated food increases when consumers are provided with information about specific advantages of the radiation process (CAST, 1996).

A survey conducted by Resurreccion et al. (1995) showed that 72% of respondents were aware of irradiation, but 87.5% of those did not know much about it. Survey participants expressed less concern about food irradiation than food additives, pesticide residues, animal drug residues, growth hormones, and bacteria. Risks to workers and the environment were among the top concerns expressed about irradiation. Further, Resurreccion et al. (1995) found that 45% of the consumers would buy irradiated food, 19% would not buy it, and the others were undecided. Bruhn (1995) reported that the number of consumers concerned about the safety of irradiated food decreased from 42% to 35% in the last six years and was less than the number concerned about pesticide residues, microbiological contamination, and other food-related issues. Shin et al. (1992) reported that consumers were willing to pay up to $0.81 per meal, more than 10-fold greater than the cost of irradiating food (Morrison, 1989), to avoid foodborne illness.

**Summary**

Irradiation of food can effectively reduce or eliminate pathogens and spoilage microorganisms while maintaining wholesomeness and sensory quality. Selection of appropriate treatment conditions can minimize or prevent objectionable changes in food quality. Methods to detect foods that have been irradiated are becoming internationally accepted. When informed of the benefits of irradiation, consumers are willing to purchase irradiated foods, even at higher cost.

**References**


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Food Irradiation’s Advantages Will Not Escape Public Attention

The approval by the U.S. Food and Drug Administration of meat irradiation on December 2, 1997 has been universally hailed. Even some advocacy organizations and individuals that formerly opposed the procedure for a variety of reasons have been positive in their responses to this development.

The Scientific Status Summary, prepared by Dr. Dennis Olson for IFT’s Expert Panel on Food Safety and Nutrition, that follows is an excellent analysis of the tortuous history and the science that preceded the approval. IFT members and others will benefit from this readable and informative paper. Olson’s eminence in the field and his pioneering efforts to provide answers to this and other leading edge technologies are well-known and much respected.

The eagerly awaited approval of this technology by FDA was preceded a few weeks earlier by a meeting organized jointly by the World Health Organization (WHO), the United Nations Food and Agriculture Organization, and the International Atomic Energy Agency. The findings of that meeting were extremely reassuring. The experts concluded that there was no unsafe level of food irradiation. This dramatic statement was emblematic of the already demonstrated scientific fact that food irradiation is eminently safe.

Public acceptance remains something of a conundrum. Why should people accept irradiation of all things medical and not that of foodstuffs? Forty irradiation facilities in the United States (25% of the world’s commercial irradiation facilities) sterilize all types of medical equipment including implants, intravenous fluids, instruments, gloves, bandages, gowns, sutures, and drugs. Additionally, foods for the immunocompromised and for astronauts may be legally irradiated.

My prediction is that public acceptance in this country has arrived. This is due to a remarkable concatenation of events including the gradual public recognition of the horrific nature of the Escherichia coli O157:H7 syndrome and certain other foodborne diseases, the strong stand of conscience on food irradiation made by the WHO, and the historic FDA approval. Although it has always been fashionable to criticize the FDA, all must admit to the enormous global significance of each and every finding the agency makes. Just during the past five years the heroic approval processes that resulted in the FDA stamp of approval on petitions as diverse as bovine somatotropin (BST), bioengineered foods, and Olestra have markedly transformed public opinion. And the credibility of WHO in scientific veracity is essentially unchallenged. Finally, food safety knowledgability has clearly improved over the past ten years and most Americans now seem to understand that the real threats in the food supply are not things chemical but things microbiological.

Prior to the 1990s, most U.S. citizens generally felt that food safety problems could be handled either by regulation or by antibiotics. But when the government exercised its authority to declare a pathogen illegal and this came to no avail, the lesson was not lost on a goodly number of people. Moreover, the current national debate over antibiotic resistance carries with it the sobering premise that things are so bad it is medically unsound to treat salmonellosis with antibiotics because such therapy will only reduce levels of competitive bacteria thus exacerbating the salmonella infection. Armed with such facts and exercising its collective wisdom some, if not most, of the public has concluded that for food to be truly safe there must be a kill step prior to cooking. The only viable solution to this enigma is irradiation. It is, of course, possible to come to this conclusion with reservations. Cardinal among these reservations is the necessity of providing the public an option via labeling. Others evince the caveat that the public must be educated to comprehend that one cannot treat irradiated foods like one treats Ultra High Temperature (UHT) milk. Notwithstanding this, it must be gainsaid that the primary advantage of food irradiation to the world at large may be shelf life extension which is in most instances doubled.

It is my firm belief that Americans are going eventually to love the idea of irradiated food. Especially when they find out it does not look different, it does not taste different, it will deliver the same nutrients and, most important to most, the same satisfaction. The food scares of the future that will be emblazoned across the front pages of our newspapers will not come from irradiated food but will, predictably, come from non-irradiated food. The miseries of the dairy industry—salmonella, Brucella, Listeria, and all the other grisly visitors—come from unpasteurized milk and, more and more, unpasteurized cheese. This has not escaped public attention and neither will the food safety advantages of food irradiation. When this becomes ingrained upon the American psyche in 2000 or 2010 or whenever, then the clarion cry of a new breed of consumerists might well be, "What can we do to get more of our food irradiated?"

On a recent national call-in radio program, I was confronted by the hostess in the last minute of the 45 minute show with the dilemma that dozens of people were waiting on the line with questions about food irradiation. I was asked what should the network say to them. In the expediency of the moment, I responded, "Tell them it is safer to irradiate the food than to not irradiate it . . . ." That was the last word then and it is the last word now.
CHICAGO—Minimally processed. Convenient. Nutritious. And tasty! These words capture consumer demand for foods today. This demand is a challenge for the food industry because it must also consider the microbiological safety, shelf life, and packaging of such foods, notes Elmer H. Marth, Ph.D., author of the Institute of Food Technologists' (IFT's) Scientific Status Summary "Extended Shelf Life Refrigerated Foods: Microbiological Quality and Safety."*

"Increasingly, all types of consumers are demanding minimally-processed foods that are high in quality, nutritionally superior, and easy to prepare," he says. "Food processors have met this demand by developing refrigerated foods with extended shelf life, [such as] complete heat-and-eat meals, fresh pasta, and [pre-washed or deli-style] salads."

However, contrary to past conventional wisdom, scientists now know that several pathogens, such as *Escherichia coli* O157:H7, *Listeria* species, and certain strains of *Clostridium botulinum*, can grow at refrigeration temperatures, which means that manufacturers must stringently apply control measures to refrigerated foods with extended shelf life.

According to Marth, good manufacturing practices (GMPs), sanitation, and hygiene are key to microbiological control. These include using high-quality raw materials with low levels of microorganisms, selecting food processing equipment that is easy to clean and does not harbor contaminants, sanitizing equipment regularly to prevent build-up of bacteria, checking equipment for cleaning adequacy with microbiological tests, filtering the air of food processing areas to reduce airborne contaminants, and training personnel to use hygienic food handling practices. Expanding upon GMPs, establishing a Hazard Analysis Critical Control Point system is also important to fully identify and control food safety hazards. Beyond food production, acceptable product storage temperature and time must be established and carefully monitored.

(more)
The heat treatments used for refrigerated products with extended freshness are lower than those used to sterilize food, thus, they may effectively inactivate bacteria, but not microbial spores. These spores can germinate and grow under conditions caused by product abuse, Marth notes. Proper handling after heating is critical to avoid introducing microbial hazards.

Other control measures that may enhance food safety and are commercially applied include irradiation (approved for meat and poultry, but not seafood), the bacteriocin nisin (an anti-microbial protein produced by certain bacteria), and high hydrostatic pressure.

Spoilage microorganisms, such as yeasts, molds, and *Lactobacillus* bacteria, are also a concern with refrigerated foods because they may alter product appearance, taste, texture, and odor, Marth says. For example, some species of *Lactobacillus* produce acetic and formic acid, ethanol, and carbon dioxide, which can spoil a variety of foods, including milk, meats, vegetables, fruit juices, sugary products, alcoholic beverages, and products containing vinegar.

Modified atmosphere and aseptic packaging are useful in extending the freshness of refrigerated products by reducing oxygen and/or increasing gases like carbon dioxide in the food environment, which inhibits bacterial growth. As with all food processing steps, however, such packaging must be used with control measures to be effective, Marth notes.

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*Founded in 1939, IFT is a non-profit scientific society with 28,000 members working in food science, technology and related professions in industry, academia and government. As the society for food science and technology, IFT brings sound science to the public discussion of food issues.*
Insufficiently cooked ground beef was identified as the cause of a 1993 outbreak of *Escherichia coli* O157:H7 illness in the Western United States when four children died and over 700 people became ill. The magnitude and media coverage of this and other recent foodborne illness outbreaks have helped elevate public awareness of foodborne microbial pathogens.

The food industry and Federal agencies are enhancing their efforts to improve and ensure the safety of U.S. foods. These efforts include providing consumers with safe food handling information; revamping the inspection systems for meat, poultry, and seafood; and exploring alternative production processes to reduce pathogen contamination in animals and foods. One of the processes believed to be effective in reducing pathogen contamination is irradiation.

Irradiation can offer consumers safer foods by controlling or reducing microbial pathogens which cause foodborne illness (see box). Irradiation can also extend the shelf-life for some perishable food products, such as potatoes and strawberries. In the United States, irradiation is approved to control insects in foods and to delay ripening and sprouting in fresh fruits and vegetables. Federal regulators have also approved irradiation to decontaminate spices and dried vegetable seasonings. Among meat, poultry, and seafood products, Federal regulators have approved irradiation for pork and poultry. Approval of irradiation of seafood and other meats—including ground beef—is pending Federal review.

Technical feasibility and regulatory approval of irradiation do not ensure its commercial adoption by the food industry. For companies to adopt irradiation, they must find that irradiation improves food quality and safety at a lower cost than do other technologies and they must be convinced that consumers will buy irradiated food products.

Other processes, such as chemical and heat treatments, can also kill insects, mold, and microorganisms, including microbial pathogens in

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**Irradiation Kills Foodborne Pathogens**

Irradiation is a process that exposes products to ionizing radiation. Ionizing radiation has sufficient energy to remove electrons from atoms, creating positive and negative charges that harm or kill the rapidly growing cells of insects, molds, and microbial pathogens.

The U.S. Food and Drug Administration (FDA) permits three types of ionizing radiation to be used on foods: gamma rays (from radioactive isotopes cobalt-60 and cesium-137), high-energy electrons, and x-rays. The latter two types of radiation are produced by electron accelerator machines powered by electricity. FDA has established maximum energy levels for these machines to prevent the treated foods from becoming radioactive. The energy levels of the gamma rays are too low to induce radioactivity.

The effects of the radiation depend on the dose absorbed by the food, measured in kilograys (kGy). Doses of 2.5 to 3.0 kGy are sufficient to control or reduce many of the foodborne pathogens, such as *Salmonella*, *Escherichia coli* (E. coli) O157:H7, and *Vibrio vulnificus*, that may be found in or on meat, poultry, and seafood. Higher doses would be needed to control or reduce viruses and the spores of spore-forming bacteria, such as *Clostridium botulinum*.

Radiation doses of 2.5 to 3.0 kGy do not make meat, poultry, and seafood sterile and shelf-stable. Meat, poultry, and seafood irradiated at these doses are still perishable, and must be refrigerated and handled properly to be protected from recontamination.
Food. However, chemicals can leave residues, and heating a food changes its texture, color, and flavor. Irradiation, on the other hand, achieves its effects without significantly raising the food's temperature, leaving the food closer to its unprocessed state. Some studies have found that irradiation can create off-flavors, odors, and discoloration in beef and chicken, although other studies found no such effects. Irradiation dose, product temperature, and packaging used during irradiation play a role in the extent of these effects.

**Irradiation Approved for Pork and Poultry, But Not Yet Beef**

Use of irradiation on foods requires approval by the U.S. Food and Drug Administration (FDA). In the case of meat and poultry, USDA's Food Safety and Inspection Service (FSIS) must also grant approval. At the current time, Federal regulators have approved two uses of irradiation for meat and poultry: inactivating *Trichinella spiralis* (the parasite responsible for causing trichinosis) in fresh or previously frozen pork, and controlling *Salmonella* and other pathogens, including *Campylobacter* and *Listeria monocytogenes*, in uncooked poultry. Although irradiation of pork to control *Trichinella spiralis* was approved in 1986, it has never been used commercially in the United States.

FDA approved irradiation of poultry to control foodborne pathogens in 1990, and FSIS gave its approval in 1992. Doses of 1.5 to 3.0 kilogramays (kGy) can be used on fresh or frozen uncooked whole carcasses and parts, including ground, hand-honed, and skinless poultry, as well as mechanically separated poultry products. Cooked or cured poultry products or those containing added ingredients may not be irradiated under the regulation.

To reduce the possibility of recontamination, poultry must be irradiated in its final retail package. The packaging must allow oxygen, but not moisture or microorganisms, to enter and leave the package. Retail packages of irradiated poultry must carry the statement “Treated with Radiation” or “Treated by Irradiation” and the logo shown below.

In 1993, Vindicator, Inc. (now FOOD TECHNOLOGY Service, Inc.), of Plant City, Florida, began irradiating poultry products for the retail and foodservice markets. Currently, all of FOOD TECHNOLOGY Service, Inc.'s, irradiated poultry goes to healthcare and foodservice outlets.

In the summer of 1994, Isomedix, Inc., in Whippany, New Jersey, petitioned FDA to approve irradiation of nonfrozen red meats with a maximum dose of 4.5 kGy and frozen red meats with a maximum dose of 7 kGy to control foodborne pathogens (the radiation dose for frozen meat must be higher to achieve the same pathogen destruction). The petition includes ground meat as well as cuts. FDA is reviewing the petition, and FSIS must grant approval before irradiation can be used on beef in the United States.

**Pathogens in Ground Beef Pose Health Risks and Costs**

Foods most likely to carry pathogens are high-protein, nonacid foods, such as meat, poultry, seafood, dairy products, and eggs. Ground beef poses higher food safety risks than other cuts of beef because the grinding process spreads any pathogens that may be present on the surface of the meat throughout the ground beef. Also, an individual hamburger patty may contain meat from many cattle, thereby increasing the risk of contamination. When the hamburger patty is insufficiently cooked, pathogens in the middle of the patty can survive. Whether consumers get sick depends on a number of factors, including the type and number of pathogens ingested and the health of the individual. Two illnesses associated with ground beef are *E. coli* O157:H7 disease and salmonellosis.

**E. coli O157:H7 disease**

According to the American Gastroenterological Association, between 10,000 and 20,000 cases of *E. coli* O157:H7 disease occur each year in the United States. The disease usually produces a mild gastrointestinal illness that occurs 3 to 5 days after eating contaminated food. However, *E. coli* O157:H7 disease can result in two serious illnesses requiring hospitalization—hemorrhagic colitis and hemolytic uremic syndrome.

Hemorrhagic colitis is distinguished by the sudden onset of severe abdominal cramps and diarrhea which is often bloody. Approximately 16 percent of the annual cases of *E. coli* O157:H7 disease develop hemorrhagic colitis, mostly young children.

Less than 5 percent of *E. coli* O157:H7 disease cases develop hemolytic uremic syndrome. However, it is a severe, life-threaten-
ing illness characterized by red blood cell destruction, kidney failure, and neurological complications, such as seizures and strokes. Most hemolytic uremic syndrome cases occur in children under 5 years old, although the elderly may also be at risk.

The U.S. Centers for Disease Control and Prevention (CDC) estimates that 49 percent of the annual cases of E. coli O157:H7 disease (4,900 to 9,800) are due to consumption of insufficiently cooked ground beef. USDA's Economic Research Service (ERS) estimates that these cases result in $196 million to $441 million, respectively, in annual medical costs and productivity losses. (The range of costs reflects the range of estimated cases; all illness costs are in 1995 dollars.) Medical costs include expenses for doctor visits, medicine, and hospital care. Productivity losses refer to wages lost from missing work due to illness or premature death.

Salmonellosis

The CDC estimates that 800,000 to 4 million cases of salmonellosis occur each year in the United States. Illness from the bacterium Salmonella usually appears 6 to 72 hours after eating contaminated food and lasts for a day or two. Common symptoms are nausea, diarrhea, stomach pain, and sometimes vomiting. In rare cases, salmonellosis, like many other bacterial and parasitic infections, can cause chronic disease syndromes, such as arthritis and meningitis. Although the illness is generally regarded as a relatively mild disease, death can occur in some cases—especially for the very young, very old, or immunocompromised.

USDA estimates that 3 percent of the annual cases of salmonellosis (24,000 to 120,000 cases) are attributed to consumption of insufficiently cooked ground beef. ERS calculates that the annual medical costs and productivity losses for these cases range between $30 million and $111 million, respectively. Although more people are stricken with salmonellosis than with E. coli O157:H7 disease from eating ground beef, medical costs and productivity losses from salmonellosis are lower because the disease is generally less severe.

Therefore, annual medical costs and productivity losses related to salmonellosis and E. coli O157:H7 disease from eating ground beef total between $226 million for the lower end of the estimated annual number of cases to $552 million for the higher end of the range (table 1).

| Table 1 |
|---|---|---|
| **Two Illnesses Related to Ground Beef Consumption Cost Up to Half a Billion Dollars a Year** |
| **Illness** | **Estimated cases per year** | **Estimated medical costs and productivity losses** |
| | **Number** | **Million dollars** |
| Salmonellosis | 24,000-120,000 | 30-111 |
| E. coli O157:H7 disease | 4,900-9,800 | 196-441 |
| Total | 28,900-129,800 | 226-552 |

Note: In 1995 dollars.

Irradiating Ground Beef Can Produce Societal Benefits

Societal benefits from irradiating ground beef would come from the savings from fewer foodborne illnesses. If the savings exceed the industry costs of irradiation, there are positive net societal benefits. FDA and FSIS have not approved irradiation of ground beef, so we have no commercial experience from which to derive costs for the irradiation treatment.

A 1989 ERS study on the costs of irradiating chicken and other foods gives us an idea of the costs of irradiating ground beef. The 1989 study looked at the investment and operating costs for various sized hypothetical irradiators physically integrated into chicken processing plants. The study assumed the plants had to be fitted with thick concrete walls and labyrinth arrangements to shield workers from the radiation. The volume of food irradiated is critical to unit costs because of the multimillion dollar initial investment required to add irradiation equipment and shielding to a plant.

Some of the larger beef processing plants in the United States that prepare ground beef for fast-food establishments and retailers handle up to 250,000 pounds a day, or about 65 million pounds a year. Assuming the plant operates 5 days a week, year round. In the 1989 study, it cost 1.3 cents per pound to irradiate 50 million pounds of food a year. Irradiators treating smaller volumes would incur higher treatment costs per pound. For example, irradiation costs were close to 4 cents per pound for an irradiator treating 12 million pounds of food a year.

The size of the net societal benefits depends on the cost of irradiating ground beef and the extent of the foodborne illnesses prevented. Technical and economic considerations make it unlikely that the entire
U.S. ground beef supply would be irradiated if regulatory approval were granted. In the United States, if 25 percent of the 7 billion pounds of ground beef consumed in 1995 was irradiated and this treatment successfully prevented 25 percent of the ground-beef-caused salmonellosis and E. coli O157:H7 disease associated with ground beef consumption would be prevented. The 1989 ERS study by the producer price index for capital equipment to approximate the higher costs that meat processors would face in building and operating an irradiator in 1995. Comparing these costs and benefits yields net societal benefits of $28.1 million to $109.4 million per year (table 2). Therefore, the savings from reduced cases of salmonellosis and E. coli O157:H7 disease from consumption of ground beef outweigh industry costs of irradiating the food.

This 1.6-cents per pound treatment cost understates the cost of irradiation for smaller volume plants and for plants that do not have irradiation facilities on site. A meat processing plant that sends its products to a contract irradiator would be charged a fee for the irradiation treatment and for shipping. Assuming a higher irradiation cost of 5 cents per pound (roughly equal to the 4-cents per pound cost from the 1989 study when adjusted to 1995 prices) for all meat processing plants, it would cost $88.5 million to irradiate 25 percent of the U.S. ground beef supply. Under the lower societal benefits estimate of $56.4 million, industry costs for irradiation are $32.1 million higher than the societal benefits from saved medical costs and productivity losses (table 2). When societal benefits are estimated at $137.7 million, societal benefits outweigh industry costs for irradiation by $49.2 million.

The 1989 irradiation study reflected technology at the time of the analysis. Several U.S. engineering companies are trying to develop both isotope and electron accelerator systems that can more easily fit into a plant’s numerous processing lines. These “on-line” irradiation units are being designed to be self-shielding and not require the separate concrete irradiation chamber assumed in the ERS study. The designers of these systems anticipate treatment costs will be lower than those of the present food irradiation systems.

**Potential Market for Irradiated Meats**

Despite scientific evidence of the effectiveness and safety of irradiation and regulators’ approval of selected uses of the process, few food processors and retailers are offering irradiated products. Some processors and retailers are uncertain about whether consumers will buy irradiated products and fear boycotts threatened by groups opposed to food irradiation.

These groups claim that irradiation may cause genes to mutate and become cancerous. They also argue that long-term health effects from consumption of irradiated foods have not been examined thoroughly and are, therefore, unknown. Some people oppose irradiating food because they regard this as an act of tampering with nature. Others question the need for food irradiation, calling for foodborne illness to be minimized by more stringent Government inspection, higher food-safety standards, and more careful food preparation practices by consumers.

While some consumers may not be willing to buy irradiated meat, recent consumer surveys suggest that there may be potential markets for irradiated meat.

In a 1996 Food Marketing Institute telephone survey of adult grocery shoppers, 47 percent of the 1,007 respondents had heard nothing about irradiation, the purpose of which was described as “to reduce spoilage and harmful bacteria without leaving residues or affecting product flavor.” Seventy percent of those who had some knowledge of irradiation, however, stated that they would likely buy “a food product like strawberries, poultry, pork, or beef if it had been irradiated to kill germs or bacteria.” By comparison, 58 percent of those who had...
some knowledge of irradiation said they would buy irradiated food if it had been irradiated “to keep products fresh longer.”

Similar findings were also noted in a study conducted for the American Meat Institute Foundation. In a 1993 national telephone survey of 1,005 adults, 54 percent of the respondents said they would buy irradiated rather than nonirradiated meat after being told that irradiation can kill the bacteria that cause foodborne illness and are contained in raw meat. Furthermore, 60 percent said they were willing to pay 10 cents more than the regular price of $2.00 for hamburger “with bacteria levels greatly reduced by irradiating the meat.”

Market evidence also demonstrates the extent of acceptance of irradiated foods. For example, Carrot Top, Inc., a grocery store in Northbrook, Illinois, introduced irradiated produce and chicken for sale in 1993, after a consumer education campaign to explain relevant issues of the technology. The irradiated boneless, skinless chicken breasts were priced competitively with similar chicken breasts in local stores. According to the firm, the irradiated chicken breasts sold well. Carrot Top, Inc. has not carried irradiated chicken since mid-1995 because of lack of supply, but still carries irradiated fruits and vegetables.

In a 1995-96 market experiment by Kansas State University, about 40 percent of shoppers at two grocery stores in Manhattan, Kansas, chose irradiated chicken over the store brand when the two products were priced the same. The proportion of shoppers who purchased irradiated chicken rose to 60 percent when the irradiated chicken was priced 10 percent lower than the store brand chicken.

Education about food irradiation appears to increase consumers’ willingness to purchase irradiated ground beef. After answering a questionnaire on food safety and irradiation, 52 percent of the 104 consumers in a simulated supermarket setting experiment in Georgia purchased ground beef labeled as irradiated rather than regular ground beef when both products were priced the same. After the participants were given more information on irradiation, 71 percent purchased ground beef labeled as irradiated when priced the same as regular ground beef. (The ground beef labeled irradiated had not actually been irradiated, and the participants were informed of this after the experiment.)

Outlook for Ground Beef Irradiation Uncertain

The marketing of irradiated ground beef faces hurdles. Irradiation of ground beef awaits approval by FDA and FSIS. Although irradiating ground beef would likely reduce foodborne illness and extend shelf-life, there may be insufficient demand. To date, the market for irradiated pork has not developed, while the market for irradiated poultry is limited primarily to healthcare and foodservice establishments. Irradiated ground beef may be more suited to fill these niche markets. Some consumers are at greater risk from foodborne illnesses because of their age or weak health, or because they do not have control over their own cooking, such as with nursing home residents and hospital patients. For example, Marriott, at the request of their clients, buys irradiated chicken from FOOD TECHNOLOGY Service, Inc., to use in their foodservice operations in hospitals and nursing homes in some Southeastern States. Some large fast-food chains serving hamburgers may also be interested in irradiation’s potential for preventing foodborne illness outbreaks that may be traced back to their restaurants.

The food industry needs more certainty of sufficient consumer acceptance of food irradiation before adopting the technology. Also, producers, retailers, and foodservice operators will consider the cost of irradiation compared with other technologies for reducing pathogen contamination of foods.

References


